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NOTES ON PRELIMINARY AND LOCATION RAILROAD SURVEYING IN THE WEST.

BY W. NEWBROUGH.

IT is the purpose of this paper to give some notes on railroad surveying as practiced in Kansas, the Indian Territory and the Panhandle of Texas, by engineering parties of the Atchison, Topeka & Santa Fé Railroad Company, during the year 1886 and 1887.

The method given is thought to be advisable for the vigorous prosecution of the work.

A surveying party for preliminary or location work is organized about as follows: Locating engineer, transitman, levelman, topographer, head and rear chainmen, rodman, stakemarker, two axemen, rear flagman, line teamster, three camp teamsters, a cook and night herder.

Sometimes an assistant locating engineer is added, and sometimes the topographer is dispensed with.

The company lays great stress on the idea of trying every possible line, especially on preliminary work. First, because when the work is to be located, there should be no hesitancy, nor useless trial of lines by the engineer, but the maps and profiles should show at a glance what is to be done. Secondly, because the engineer on location might possibly overlook the best line by depending on the preliminary map and profile.

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37-26

When an assistant engineer is present the topographer is usually dispensed with, and his work is divided between the engineer, assistant, transitman and levelman.

It remains an open question whether it is not poor economy to be without a topographer, as the maps and profiles are not so complete, or so well executed as when he is on the party.

As a rule the hind chainman is given charge of the chain and he attends to keeping it in order and to checking its length, etc. He usually also carries a book and enters into it the stations which are transit points, the stations and places at which the line intersects section-lines, and the distances and direction of the section-corners from these stations and places, and consequently is able to check the notes of both the transitman and the topographer to a certain extent.

The rear flagman on arriving at a hub immediately holds his rod on the tack and keeps it there until signalled to come up to the next hub.

By this means the transitman can turn on the back sight at any moment and be sure of getting his sight, and not having to walk back from a thousand to fifteen hundred feet in order to awake his back flagman from sleep—that has occurred more than once. Sometimes there is no back flagman on the party, but a lath with a small piece of red muslin acts as such, being stuck behind the hub by the transitman on leaving.

As regards stock, the following is a fair estimate. A four-mule line team (sometimes a span of mules are used for this work), three four-mule camp teams and from two to four saddle-horses.

On the frontier, mules are preferred to horses, because of their greater toughness and capability of enduring exposure. They have a fancy for the horses, and, by keeping track of the few saddle-horses, the mules can easily be found.

The wagons should be in good condition at starting and should be of good make; about 3¼ is the proper size for the camp wagons and from 2¾ to 3 for the line wagon. At least two of them should be fitted with a set of bows and all should have wagon sheets. The harness should be strong, and extras, such as straps, clevises, etc., should be carried along. A roll of half-inch rope should be taken for use for lariats and similar purposes.

The best canvas for tents is from 14 to 16 ounce stuff. Tent-flies are a considerable nuisance. It is true they render the tents

cooler in summer, but they are always becoming loosened and flap about very unpleasantly.

In pitching camp great care is used. One of the camp teamsters usually goes ahead and selects the spot and informs the party where it is, to avoid any chance of their being lost. He usually picks a place along some creek and above high-water mark, and when the outfit arrives the tents are pitched in the most secure manner.

In winter it is a good idea to have some iron pins made about six inches long, and to drive them into the ground directly through the holes in the canvas. This brings the canvas close to the ground, and if necessary it can be frozen fast. A monkey-wrench will loosen the pins in a few moments when moving camp.

For a party as described, there would be required, a cook tent, a dining tent, an office tent and two sleeping tents.

The locating engineer, transitman, levelman and topographer usually sleep in the office tent.

The cook selects the cooking stove, the kitchen utensils and the provisions. He generally very much under-estimates the quantity of the latter, and it is a good rule to multiply his figures by two or three.

The tables, both kitchen and office, are made with horses. The tops are in one piece and consequently serve as efficient side-boards when loading the wagons. By nailing projecting cleats on the horses and laying boards across them seats are obtained.

The stationary box is best made with a tray for holding pins, pencils, triangles, etc. It is large enough to contain books, maps, and map paper, profiles, ink, and in fact all the requirements for the clerical work of the survey.

The instruments are supplied by the company. Gurley's are mostly in use. Axes, hatchets, a grindstone, saddles, the private baggage of the party, etc., make up the rest of the *impedimenta*.

Cots are an abomination in camp. They are always in the way and take up considerable room in loading.

Each man supplies his own bedding, and a good bed is much to be desired.

Two quilts, a couple of pairs of blankets, a large piece of canvas for covering, and a small pillow constitute the usual "couch."

The medicines are of the simplest kind, and sometimes none are carried.

In winter stoves are required, and the kind of stove used varies according to the region of country.

The locating engineer is furnished from time to time with money to defray the expenses of the party.

Such a party, including the stock, will cost from $225 to $300 per month. Receipts have to be taken for everything, and are sent in to the general office with duplicate vouchers, and pay rolls, at the end of each month.

To run such a party the total cost per month is about as follows:

Expenses of party, ...	$275 00
Wages, ...	850 00
Interest on investment in tents, stock, wagons, etc., . .	25 00
	$1150 00

A survey can be run cheaper than the above, but will require more time to be finished.

In the field work, the proper placing of the line, its permanency, speed, and accuracy are all elements of good work.

Our stakes are at least 20 inches in length, 2 inches broad, and 1 inch thick, and are driven 8 inches in the ground. Hubs are 4 inches broad, 2 inches thick, and 8 inches long, and are driven flush with the ground. Benches are placed at least every 2000 feet along the line of survey.

In prairie country a bench consists of a stake driven not less than 1 foot in the ground and projecting not more than 3 inches above the surface. A guard-stake on which the height above datum is marked is placed beside it, facing the line. These benches are placed from 50 to 100 feet to the right or left of the line. Benches are also usually placed near creeks, ravines, etc., where bridges will be required.

In "setting a hub" the Santa Fé rules require that it shall be "double centred."

This method fixes the tack correctly, no matter how far the line of collimation may be out of adjustment.

In the climates of the Territory, Texas, Kansas, and eastern Colorado, I have found it advisable to use no oil on the centres of instruments. Polishing them with a chamois skin and, if neces-

sary, rubbing a very little graphite on the centres, will cause them to move at the lightest touch.

It is usual to check all angle readings by means of the needle, instead of by reading both verniers. It is more rapid, and there seems to be less liability to error.

On prairie work, 2000 feet for the transit and 500 feet each way for the level is about the maximum sight. If further distances are used, there is liable to be inequality in the sights and consequent delay of the party.

A gradienter is very handy on a transit, especially on a supported grade. It is quicker to operate than the vertical arc, requires no calculation, and there is very little liability to error in using it.

The line has to be tied to section-corners wherever they occur. It is done in this way: When the chainmen come to a section line a stake is set on it and the station and plus, if any, is marked on the stake. The chainmen then immediately measure to the corner and the hind chainman notes the station, distance, and direction in his book. They then return to the stake and the sight is run out. The transitman now picks up his instrument and goes to the stake, sets up over it, measures the angle, enters the station and angle in his book and proceeds to the next hub.

This method necessitates the delay of the whole party while the chainmen are measuring to the corner. If an extra man is on the party it is advisable for him and the line teamster to take these measurements, and thus delay is avoided.

Towns are tied to the railroad line by projecting the centre line of the streets upon it, and noting the station and angle which they make with it.

In easy country, on preliminary work, the chainmen often do not wait for the transit to come up at the close of each sight, especially if on a tangent. They proceed immediately after the hub is placed, set the stakes by eye, and by the time the transit is ready at the hub, are ready to set the next one. This is a very speedy method where the level work is easier than the transit work, but is not advisable in country where the levelmen cannot keep up.

The speed of a party depends so much both upon the party itself and the nature of the country that it is hard to give any

figures. Sometimes a half mile is a good day's work, and at others eleven and twelve have been covered.

The greatest speed I know of is 8 miles and 1100 feet in five hours. This was accomplished on a tangent on the Staked Plains, the transit setting every stake.

The transit and level work is much more accurate than is generally supposed, considering the speed that is attained.

In seven months' continuous transit work in 1887, running short traverses from two to twelve miles in length two or three times a week, there never occurred a greater error than two minutes, nor a greater error than two-tenths of a foot in the level work.

The headings of the note-books for preliminary work are the following:

Station. | Points. | Description of Angle. | Calculated Course. | Magnetic Course. | Remarks.

It is usual to start the calculated course the same as the magnetic and not to add or subtract the variations.

Unless the ground is considerably broken or rolling it is not the practice to take contours. For ordinary slopes hatchuring is considered sufficient.

The locating engineer is furnished by the chief engineer with values for equating length of line, curvature, bridging, earthwork, etc.

Extra length of line is estimated at $5.00 per foot; curvature at from $10.00 to $15.00 per degree; bridging, about $8.00 per foot, and earthwork at 10 cents per cubic yard. Loose rock is valued at 75 cents per yard, and solid rock at $1.00. These values enable the engineer to compare the relative cost and values of two or more lines with considerable certainty.

The maximum gradient is in all cases understood as belonging only to straight lines, and the rate of ascent upon all curves is sufficiently less than the maximum to compensate for the assistance to traction due to curvature.

When the rate of maximum on a straight line is 0.6 or less per 100 feet, the compensation for curvature is 0.06 foot per degree. When from 0.6 to 1.6 per 100 feet, the compensation is 0.05 foot per degree, and when from 1.6 to 3.0 per 100 feet, it is 0.04 per degree.

The levelman's book is headed as follows:

Station. | + Sight. | Height Instrument. | — Sight. | Elevation. | Remarks.

In it are kept the elevations of all stations and very often the sizes of all the bridge openings

On preliminary work, especially when the country is unsettled, it is a good idea to keep a traverse of the line and to plot the map by latitudes and departures. This traverse, in addition to the plotting, will give at a glance the easting, westing, northing, or southing from the starting-point, and will also be quite an aid in calculating minor traverses when the line comes to be located.

It is unnecessary to do this in a country like Kansas, where the section lines are all surveyed and where it is possible to tell all about distances and directions by means of them. In this kind of country and for location work a 14-inch cardboard protractor graduated to quarter degrees will plot accurately enough for all practical purposes, and is much more rapid than the traverse.

The maps are made on a scale of 2000 feet to the inch, except at towns and important places, where 400 feet to the inch is generally used. In plotting it is best to plot the line first and to put in the section lines accordingly. If this is done everything will fit, while if the section lines are plotted first, considerable "fudging" will have to be done, due to poorly-run section-lines and to their convergence. On the maps, in addition to the line and topography, are placed the distances and directions of section corners, owner's names, notes of camping-places and of springs, wells, etc., and also lines worthy of trial. These last are usually dotted.

The profile is plotted up to date every night, and the grade lines and bridge and borrow ditch notes are put on it in pencil. As soon as possible these are inked in and the estimates are put on.

To get the length of a pile-bridge we take the fill, multiply it by 3 (as the slope is 1½ to 1 on each end), add the opening and add 10 to get a good bearing on each end. Thus, suppose the fill is 12 feet and the opening 20. We have $12 \times 3 = 36 + 20 = 56 + 10 = 66$ feet. But as bridges come in 15 feet bents, we will make this 60 or 75 feet long, according to judgment.

Notes of the *per cent.* of loose and solid rock, and of the drain-boxes and pipes are put on each section of the profile. The earth-work is calculated from level cross-section tables. On each section there appears a table about as follows:

Earth excavation—yards. Earth embankment—yards. Solid rock—yards. Loose rock—yards. Pile bridging—lineal feet. Trestle bridging—lineal feet. Iron drain, 24 inches—lineal feet. Iron drain, 18 inches—lineal feet. 1 × 2 box-drain—lineal feet. 2 × 2 box-drain—lineal feet.

Sometimes the section lines are put on the profile, east and west lines sloping upward to the right, and north and south lines to the left.

Location Work.

In putting in a curve with the transit the A. T. & S. F. rules require, except upon precipitous and impracticable ground, that the transit shall be set up at the P. I., and the P. C. and P. T. set, and that the succeeding tangent shall be produced as a prolongation of the line joining the P. I. and P. T., rather than from the curve itself. Their rules also state that curves of a rate less than one degree per hundred feet should not be used unless the intersection angle is less than three degrees. All curves should be at least three hundred feet in length. Curves in opposite directions should be separated by a tangent not less than two hundred feet long.

Three-centred and transition curves are not used in new lines. A curve is not "eased up" until the traffic requires it.

30′, 1°, 1° 30′, 2°, 2° 30′, 3°, 3° 30′, 4°, 5°, 6°, and 7° 30′ curves are mostly in use. Curves of over 10° must not be used without special instructions from the chief engineer.

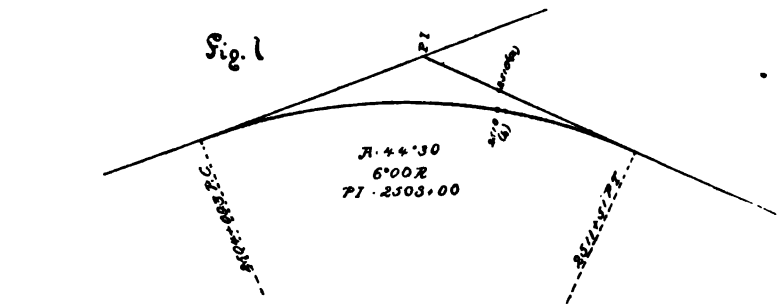
My usual method when putting in a curve, which can be seen all the way around, if the party is experienced, is as follows:

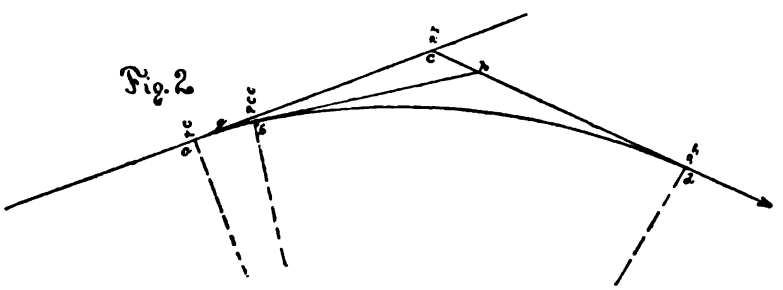
1°. Set up at P. I., and turn the angle and set the P. T. by "double centring." 2°. Set the P. C., leave the chainmen there, and call the back flag up to the P. I. 3°. Remove the transit to the P. T., and turn on the P. C., and run in the curve, the chainmen working toward the transit. When finished, the transit should check on the P. I. The instrument can now be revolved on the horizontal axis and the succeeding tangent produced.

The advantage of this method is that it requires but two "set ups" of the transit. Its disadvantage is that until the chainmen become used to it it is difficult for them to chain rapidly toward an instrument on a curve.

Frequently the P. T. of a curve will be in a hole or invisible

from the P. I. by reason of the adjacent topography, but a point between it and the P. I. is visible, and from this last the P. T. can be seen. Such a state of affairs will usually necessitate a set up on the curve near the point between the P. I. and P. T. Thus, Fig. 1. Sta. 2510 (a) is visible from P. I. and P. T. is visible from it. Sta. 2510 (b) is visible from P. C. and P. T. is visible from it.





Transit is at P. I. Set a hub at 2510 (a) and set the P. C. Move to P. C. and run curve around to 2510 (b). Move to 2510 (b) and run to P. T. of curve, setting the staff in the ground at that point. Now move to 2510 (a) and set the P. T. hub and produce the tangent P. I.–P. T. The advantages of this method are that the points (a) and (b) are close together, and that it is frequently possible to avoid the set up at 2510 (b) if it is close to the P. T.

Another problem which often arises when leaving a constructed line or a yard is as follows. It is in reality a track problem and does not properly belong to location work but is sometimes encountered.

It is required to start from a tangent *ac* with a curve of a certain

degree, say 7°30′, and after going a certain distance, say 110 ft, to change to a curve of different degree, say 5° 0′, and there to merge into a fixed tangent, as *cd* (Fig. 2). The problem is to find the points *a* and *d*.

Suppose the angle is 44° 30′.

Now 110 ft. of 7° 30′ curve = 7° 52½′, and the tangent of this is 52.6 ft. = *ag* or *gb*. The remainder of the angle is 44°30′ — 7°52½′ = 36°37½′, and the tangent for this on a 5°0′ curve is 379.4 ft.— *bh*. Hence *gb* + *bh* = 52.6 + 379.4 = 432.0 ft. = *gh*. Then, in the triangle *gch*, we have

Sin 44°30′ : 432 :: sin 36°37½′ : *gc* or *gc* = 367.7
Sin 44°30′ : 432 :: sin 7°52½′ : *ch* or *ch* = 84.37
Now *ac* = *ag* + *gc* = 367.7 + 52.6 = 420.3 and
cd = *ch* + *hd* = 84.37 + 379.4 = 463.77.

Whence we have *a* and *d* and the curve can be run in.

A very usual way of doing this is to assume a point *a*, and run out the curve and then measure the distance from its extremity to *cd*, and then calculate, by dividing this distance by the sine of the angle, in this case sin 44° 30, how far back or forward the P. C. must be placed, in order that the P. T. shall be on the line *cd*.

Very often on precipitous ground, where the curve has been run in without a P. I., it is necessary to take off from or add to a curve, so that the succeeding tangent shall be a certain distance right or left of what it is, at some station beyond.

In this case it is usual to figure from the P. T. of the curve. That is, as if the P. T. was the angle point. Suppose for instance we have a 4° curve to the left, ending at station 524 + 54, and the tangent beyond must be thrown 20 ft. to the right at station 530 + 50. This is done by taking the distance 530 + 50 — 524 + 54 = 596 ft. and dividing 20 by it. This gives the sine of the angle due to the 20 feet. Find this angle and the corresponding distance on a 4° curve and take this distance off the curve. Of course this is only approximate and will throw the line a trifle more than 20 ft. to the right, because the angle is not at the P. T. from which the calculations were made. However, it is usually close enough, especially if the succeeding tangent is short.

The note-book for transit work on a location survey is headed as follows:

Stations.	Points.	Description of Curve.	Element of Curve.	Magnetic Course.	Remarks.

It is usual to keep the calculated course on the page for remarks. The second column contains the notations for transit points, P. C's, P. I's and P. T's; the third, the degree of curve, and whether to the right or left; the fourth, the total angle in the curve, the radius; the length of curve and the tangent distance; the fifth and sixth, as are indicated by their headings.

Deflections and sub-deflections on the curve are not entered in the note-book.

DETERMINATION OF INVERT-SUGAR BY ALKALINE COPPER SOLUTIONS.

BY F. G. WIECHMANN, PH.D.

INVERT-SUGAR is a mixture in equal parts of dextrose and levulose. It occurs in nature in fruits, in the leaves and in the blossoms of many plants. It can be produced from saccharose by the action of dilute acids and by ferments. Boiling with water for some time will also effect the transformation:

$$\underset{\text{Saccharose.}}{C_{12}H_{22}O_{11}} + H_2O = \underbrace{\underset{\text{Dextrose.}}{C_6H_{12}O_6} + \underset{\text{Levulose.}}{C_6H_{12}O_6}}_{\text{Invert-sugar.}}$$

The quantitative determination of invert-sugar in the presence of saccharose is a problem that has time and again occupied the attention of the most eminent workers in sugar-chemistry. Many different methods, and a still greater number of modifications of these methods, have been proposed and tried, and yet even at the present day there is no method known by which *small* quantities of invert-sugar can be determined in the presence of saccharose. In these pages, as indicated by the title, there will be considered only those methods which are based on the reaction between invert-sugar and alkaline copper solutions.

Trommer was the originator of the so-called copper test, a qualitative reaction for the detection of grape-sugar; it was communicated to the Berlin Academy of Science by Mitscherlich.*

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* Annalen der Pharmacie. Liebig & Wöhler, vol. 39, p. 360.

If a solution of cane-sugar is treated with potassic hydrate and then a dilute solution of sulphate of copper is added, the solution turns an intense blue color. If a solution of grape-sugar is treated in the same manner, after a short time, at the ordinary temperature, red suboxide of copper is precipitated. If the solution is warmed, the precipitation takes place at once.

This reaction is of great delicacy, and permits of the detection of the most minute traces of grape-sugar. A fluid which contains $\frac{1}{100000}$ of grape-sugar gives a distinct precipitate on boiling.

Trommer also advocated the use of this reaction for the quantitative determination of grape-sugar.* Barreswill greatly improved the method; Fehling, however, was the first to give exact directions for preparing the solution to be used. His formula calls for

Crystallized sulphate of copper, .	34.639 grms.	in 500 c.c. of water.
Rochelle salts, ...	173.00 grms.	in 400 c.c. of water.
And, added to this, sodic hydrate, .	50.0 grms.	in 100 c.c. of water.

Since then, however, great changes have been made by various chemists in the composition of Fehling's solution; a table given in Stammer's *Jahresbericht* for 1885 (p. 283) enumerates no less than twenty different formulæ for its preparation.

All methods involving the use of alkaline copper solutions are based on the property of invert-sugar absorbing oxygen, especially when the solution is warmed. The invert-sugar, thus acting as a powerful reducing agent, is transformed into acids whose composition and constitution are not exactly known, because, in consequence of the reagents present, these acids are again decomposed into other products.

Habermann identified carbonic and formic acids, and speaks of several others as probably present. The amount of invert-sugar is inferred from the amount of oxygen absorbed.

Formerly it was generally assumed, no matter which of the numerous so-called "Fehling's solutions" was employed, that one atom of invert-sugar reduced five atoms of copper oxide.

This, however, has long since been shown to be false, and this ratio obtains only under certain definite conditions.†

Both volumetric and gravimetric methods have been devised for

* Die Zuckerarten und ihre Derivate. Von Lippmann, p. 53.

† Claus. Journal für Practische Chemie. Series II., vol. iv., p. 63.
Soxhlet. Journal für Practische Chemie. Series II., vol. xxi., p. 238.

the determination of invert-sugar, all based on the reducing-action of this substance on alkaline copper solutions.

Volumetric Methods.

As Tucker* remarks: "There are two ways of proceeding in regard to the estimation of sugars by the Fehling process—one making use of all the refinements of more recent discovery, and requiring a considerable amount of time, being adapted for cases where the greatest accuracy is required; and the other, quickly and easily executed, but quite exact enough for many technical purposes."

The first of these alluded to is

Soxhlet's Method.†

Sulphate of copper cryst.,	34.639	grms. in 500 c.c. of water.
Rochelle salts,	173.0	grms. in 400 c.c. of water.
Sodic hydrate,	500.0	grms. in 1000 c c. of water.

Of above, take 25 c.c. sulphate of copper solution and add to it 25 c.c. Rochelle salt-soda solution (prepared by adding to the 173 grm. Rochelle salt in 400 c.c. water 100 c.c. caustic soda solution prepared as above).

Place in a deep porcelain casserole, heat to boiling, and add sugar solution until the fluid after boiling for two minutes is no longer blue.

This preliminary test indicates approximately (within about 10 per cent.) the amount of invert-sugar present. Next dilute the sugar solution till it contains about 1 per cent. invert-sugar. The true concentration will be 0.9 to 1.1 per cent., which slight deviation from the concentration desired, has no influence on the result.

Take 50 c.c. of above solution, heat, add the requisite amount of sugar solution, boil for two minutes, and then pour the whole solution through a large corrugated filter-paper. Test filtrate for copper by acetic acid and potassium ferrocyanide.

If copper is found to be present repeat the test, but take a greater volume of the sugar solution. If the filtrate is found to be *free* of copper, repeat the test, but take 1 c.c. less of the sugar solution.

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* J. H. Tucker, A Manual of Sugar Analysis, 1883, p. 186.

† Journal für Practische Chemie, New Series, 1880, vol. xxi., p. 227.

Continue with these tests until of two sugar solutions, differing from one another only 0.1 c.c., the one shows copper, and the other none in the filtrate. The amount of sugar solution intermediate between these two, must be regarded as one that will just decompose 50 c.c. Fehling solution.

1.0 per cent. of invert-sugar reduces 10.12 copper in solutions made as here prescribed. If the solution be diluted by four volumes of water, the ratio becomes 1.0 of invert-sugar to 9.7 of copper.

*Fehling's Method.**

Copper solution, as given under Soxhlet's method.†

Five, ten, or, if necessary, more grammes of sugar are weighed out, dissolved in a flask, and the solution made up to 100 c.c. The weight of sugar used varies, of course, with the nature of the sample examined, that is to say, with the amount of invert-sugar it contains; it is advantageous to have the solution of such a strength that 20 c.c. to 50 c.c. will completely precipitate the copper in 10 c.c. of the solution cited above.

The copper solution is measured out, placed in a porcelain dish and quickly brought to the boiling-point. The sugar solution is then run in from a burette (graduated in tenths of a cubic centimetre) until all of the copper in the solution is precipitated as cuprous oxide. The operator is warned of the approach of the end of the reaction by the change in color of his solution. The blue color disappears and the solution becomes colorless, or, if the sugar solution is colored, assumes a yellow tinge.

The end-point, however, is determined by filtering a few drops of the solution through paper or linen-cloth‡ into a very dilute solution of potassic ferrocyanide and acetic acid.

If a brownish-red color shows, owing to the formation of cupric ferrocyanide, two-tenths c.c. more of the sugar solution are added to

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* Annalen der Chemie und Pharmacie, 1849, vol. 72, p. 106.

† During several years of laboratory experience, the writer has found the following solution very serviceable:

Cryst. sulphate of copper, . .	34.639 grms. in one litre of water.
Rochelle salts, ...	180.000 grms. in one litre of water.
Sodic hydrate, ...	70.000 grms. in one litre of water.

The solutions were kept in separate bottles and mixed immediately before use, 10 c.c. of each being taken.

‡ Wiley, U. S Dep. of Agriculture, Division of Chemistry, Bulletin No. 15, p. 33.

the copper liquor, the solution is again boiled and the test repeated. This is continued until the addition of a few drops of the solution to the ferrocyanide no longer produces the red color.

An experienced worker rarely needs to make more than three or four of these tests before ascertaining the end point of the reaction.

As 10 c.c. of the copper solution are assumed to correspond to 0.5 gramme of invert-sugar, the calculation is an easy one. If five grammes of sugar have been dissolved up to 100 c.c., the reciprocal of the number of cubic centimetres required of this solution to precipitate all of the copper in 10 c.c. of the copper liquor, multiplied by 100, is the direct percentage of invert-sugar sought.

Tucker* gives a table for so calculating the percentages.

In December, 1884, English chemists, engaged in the sugar industry, met with the view to agreeing upon a uniform method for determining the so-called glucose in raw beet sugar.

Pending the results of careful examination into the merits of two methods, proposed respectively by T. L. Patterson and J. W. Biggart, it was decided that the determination should be made by the direct application of Fehling's method in the usual way, but with the observance of certain precautions.†

The methods referred to are here given:

Biggart's Method.‡

Solutions used:

1. An ordinary Fehling's copper solution, or any of its substitutes.
2. Acetic acid.
3. A dilute solution of potassic ferrocyanide (1 in 100).
4. A standard solution of invert sugar, 1 c.c. = .001 uncrystallizable sugar.

Weigh off 15 grammes of the sugar to be analyzed, and introduce it into a 100 c.c. flask, with a small quantity of water; add 25 c.c. of the standard invert sugar, dissolve the sugar, and make the flask up to the containing mark with water. The contents of the flask are now well shaken, and a burette is filled with the solution.

* Manual of Sugar Analysis, 1883, p. 193.

† The Sugar Cane, 1885, p. 132.

‡ *Loc. cit.*

Meanwhile, having secured a small boiling flask of about 100 cubic centimetres capacity, introduce into it 5 c.c. of copper solution, adding a few cubic centimetres of water, and place the flask over a lamp until the contents begin to boil; thereupon add 7 or 8 c.c. of the raw sugar solution from the burette, place the flask over the lamp once more, and boil for a short time. Continue additions of 7 or 8 c.c. of sugar solution with alternate boiling until the blue color of the copper has almost disappeared, after which the sugar solution is added with more caution, and the exact point at which the copper is wholly precipitated is ascertained by filtering off a small quantity of the liquid, and testing the filtrate with excess of acetic acid and ferrocyanide of potassium, when, if a red precipitate be produced, the addition of sugar solution is still cautiously continued, until the filtrate so treated ceases to give any red coloration.

Biggart also proposes a second method resting on the same principle.

The calculations involved in both are represented by the following formulæ:*

Let G equal the number of grammes weighed off or taken in the aliquot part of the filtrate.

.025 grms. = value of 25 c.c. invert sugar solution in terms of uncrystallizable sugar.

.025 grms. = value of 5 c.c. copper solution.

Let C = the number of cubic centimetres of sugar solution necessary to precipitate the copper in 5 c.c. of the copper solution.

100 c.c. = volume to which the sugar solution was made up.

Then:

$\left(\frac{.025 \times 100}{C} = .025\right)$ $\left(\frac{100}{G}\right) = x =$ per cent. of uncrystallizable sugar.

Example:

Suppose G = 14 grammes, and C = 40 c.c., then $\left(\frac{.025 \times 100}{40}\right)$ $= .0625 - .025 = \frac{.037 \times 100}{14} = .26$ per cent. uncrystallizable sugar.

After publishing his method, Biggart found certain modifications desirable. In the first place he recommends keeping in store a 15 per cent. solution of invert-sugar, slightly alkaline, to

* The Sugar Cane, 1885, p. 134.

be diluted to the proper strength when needed. Secondly, instead of determining the relation between the copper and the invert-sugar, with copper solution and invert-sugar solution alone, he arrives at the relative values in presence of an amount of pure sugar dissolved in 100 c.c., equal to the amount of raw beet-sugar which is to be used when the test is carried out.

The use of basic acetate of lead is avoided by following this modification.

Patterson's Method.

This process is intended for the estimation of the total reducing power of the sugar tested. To use the author's own words: "It may be said to be one of backward titration, in which a measured volume of Fehling's solution is boiled with a weighed quantity of the sugar under examination and the *un*reduced cupric oxide determined by means of a standard sugar solution."

Want of space forbids a detailed description of this method. It will be found in full in the reference cited.*

In 1885 Dr. A. Herzfeld† published a careful criticism on these two methods. In this review, after pointing out sources of error in both, he acknowledges them to be based on new ideas which promise some day to lead up to an exact volumetric method for the determination of invert-sugar. Both methods, he remarks, possess, in common with all volumetric methods, the advantage of permitting the Fehling's solution employed to be prepared by any formula desired.

GRAVIMETRIC METHODS.

Soxhlet,‡ in his valuable investigation already quoted, holds the gravimetric method known at that time to be not only inexact, but claims that results obtained by it must be wrong, absolutely and relatively, because no attention was paid to the influence exerted by an excess of copper.

E. Meissl,§ in 1883, published a method for the gravimetric determination of invert-sugar, in which the objections Soxhlet encountered are to a great extent overcome. The following is a translated abstract of that article:

* The Sugar Cane, 1885, p. 135.

† Zeitschrift d. V. für Rübenzucker Industrie, No. 358, p. 985.

‡ Journal für Practische Chemie. New series, 1880, vol. xxi., p. 238.

§ Zeitschrift d. V. f. Rübenzucker Industrie, No. 332, p. 765.

Meissl's Method.

Copper solution: The same as given under Soxhlet's volumetric method.

Before making this determination it is necessary to know approximately the ratio of the invert-sugar to the cane-sugar present. This may be ascertained by a preliminary test, but to obviate this, one may proceed as follows:

Assume for the moment that two parts by weight of copper reduced correspond to 1 part by weight of invert-sugar.

The *approximate amount* of invert-sugar is then $Z = \frac{Cu}{2}$.

The *approximate percentage* of the invert-sugar, and the approximate ratio between the invert-sugar and the cane-sugar, is then (after the polarization has been made) determined by the formulæ:

$$\text{Approximate percentage of invert-sugar} = y = \frac{Cu}{2} \times \frac{100}{p}.$$

$$\text{Pol.} + y : 100 :: \text{Pol.} : R.$$

$$R = \frac{100 \times \text{Pol.}}{\text{Pol.} + y}$$

and $100 - R = I$.

R and I represent respectively the ratio numbers of cane- and invert-sugar.

Executing the determination: To 50 c.c. of the Fehling solution (prepared as given in Soxhlet's volumetric method) add the requisite quantity of sugar solution (previously clarified with basic acetate of lead and sodium sulphate), make the volume of the mixture approximately up to 100 c.c., boil for two minutes, filter through an asbestos filter, reduce the Cu_2O to Cu by gentle heating in a current of hydrogen, and weigh the metallic copper.

The details of this process are thus described by Soxhlet:* Wash thoroughly a small straight $CaCl_2$ tube. Introduce asbestos fibres so as to fill about half of the bulb. Draw air through while drying, cool and weigh. Connect with aspirator, filter the precipitated Cu_2O, wash with hot water, then, having changed the receiving flask, wash twice with absolute alcohol and twice with ether. Having removed the greater part of the ether by an air-current, connect the upper part of the filter tube by means of a cork and glass-tubing with a hydrogen apparatus, and heat with a small flame whose tip is about 5 cm. below the bulb containing the Cu_2O. The reduction is finished in two to three minutes.

* Soxhlet. Journal für Praktische Chemie, vol. xxi., p. 232, 1880.

After the asbestos-tube has been cooled in the hydrogen current, air is drawn through and the tube is then weighed.

After the analysis is completed, the asbestos can be freed from the adhering Cu by washing with dilute nitric acid.

The determinations are most exact, if the amount of copper reduced weighs from 200 to 400 milligrammes. Therefore, take, if possible, so much of the sugar solution that 100 to 200 milligrammes of invert-sugar are suspected to be present; rather more than less.

In order to calculate the percentage of invert-sugar present from the weight of copper obtained, proceed as follows:

1. $\frac{Cu}{2} = Z$. Approximate absolute amount of invert-sugar.

2. $\frac{Cu}{2} \times \frac{100}{p} = y$. Approximate percentage amount of invert-sugar.

3. $\frac{100 \times Pol}{Pol + y} = R$. Ratio number for the cane-sugar.

$100 - R = I$. Ratio number for the invert-sugar.

$R : I$. Ratio of cane-sugar to invert-sugar.

4. $\frac{Cu}{p} \times F =$ correct percentage of invert-sugar.

F = factor (see following table.)

Cu = the weight of the copper.

p = the weight of the substance used.

Pol = polarization.

Z serves as guide for the vertical column.

$R : I$ serves as guide for the horizontal column.

Factors for Determining Invert-Sugar in the Presence of Cane-Sugar.

Cane-Sugar to Invert-Sugar.	Z — Milligrammes Invert-Sugar.								
R : I	245	225	200	175	150	125	100	75	50
90 : 10	56.2	55.1	54.1	53.6	53.1	52.6	52.1	51.6	51.2
91 : 9	56.2	55.1	54.1	53.6	52.6	52.1	51.6	51.2	50.7
92 : 8	56.2	54.6	53.6	53.1	52.1	51.6	51.2	50.7	50.3
93 : 7	55.7	54.1	53.6	53.1	52.1	51.2	50.7	50.3	49.8
94 : 6	55.7	54.1	53.1	52.6	51.6	50.7	50.3	49.8	48.9
95 : 5	55.7	53.6	52.6	52.1	51.2	50.3	49.4	48.9	48.5
96 : 4			52.1	51.2	50.7	49.8	48.9	47.7	46.9
97 : 3			50.7	50.3	49.8	48.9	47.7	46.2	45.1
98 : 2			49.9	48.9	48.5	47.3	45.8	43.3	40.0
99 : 1			47.7	47.3	46.5	45.1	43.3	41.2	38.1

Example: Take 26.048 grms., clarify with basic acetate of lead, and polarize. Polarization, 86.4.

Of filtrate take 50 c.c. Add sodium sulphate to remove the lead, make up to 100 c.c., and filter.

25 c.c. of this solution, corresponding to 3.256 grms. $= p$, precipitate on boiling with Fehling solution 0.290 grms. copper. From this weighed amount of copper the percentage of invert-sugar in the substance is then calculated:

1. $\frac{Cu}{2} = \frac{0.290}{2} = 0.145 = Z,$

2. $\frac{Cu}{2} \times \frac{100}{p} = 0.145 \times \frac{100}{3.256} = 4.45 = y.$

3. $\frac{100 \times Pol}{Pol + y} = \frac{8640}{86.4 + 4.45} = 95.1 = R.$

$100 - R = I,$

$100 - 95.1 = 4.9,$

$4.9 = I,$

and, therefore, the values for R : I are expressed by 95.1 : 4.9

In order to find the factor F we must hunt up the correct vertical and horizontal columns. The value $Z = 145$ is most closely approximated by the column headed 150; the ratio R : I = 95.1 : 4.9 is most closely approximated by the horizontal column 95 : 5. At the line of intersection of these two columns will be found the factor 51.2 by aid of which the final calculation is effected.

4. $\frac{Cu}{p} \times F = \frac{0.290}{3.256} \times 51.2 = 4.56$ per cent. invert-sugar.

The analysis would hence show:

Cane-sugar, ...	86.40
Invert-sugar, ...	4.56
Non-sugar, ...	9.04
	100.00

This method permits the determination of invert-sugar in the presence of saccharose, provided the amount of invert-sugar ranges from 1 per cent. upwards; Meissl believing the determination of smaller amounts of invert-sugar in the presence of saccharose not feasible.

In May, 1885, the "Verein für Rübenzucker-industrie" appointed a committee which was to examine most thoroughly into the different methods of determining invert-sugar, and to ascertain the importance of this substance in refining, in commerce, etc.

The execution of this work was assigned to Dr. A. Herzfeld.

In due time his report was made, approved of by the committee in December, 1885, and recommended for general use in Germany.

This method, which may be regarded as a modification and extension of Meissl's, is especially adapted for the determination of minute amounts of invert-sugar, a matter of very great importance to those working with beet-sugar.

Herzfeld's Method.

Copper Solution: The same as prescribed by Fehling and used by Soxhlet and Meissl.* Ten grammes of the substance to be analyzed are brought into solution. This amount (10 grs.) must invariably be used, as, otherwise, Herzfeld's table is not valid.

This solution, containing 10 grammes, may be prepared in one of the following ways:†

a. Dissolve 27.5 grammes of the sample with basic acetate of lead up to 125 c.c. To 100 c.c. of the filtrate add sodium carbonate or sodium sulphate, to remove the excess of lead make up to 110 c.c. 50 c.c. of this fluid correspond to 10 grammes of the sample.

b. 33 grammes with basic acetate of lead to 150 c.c. Of filtrate 100 c.c. with sodium sulphate to 110 c.c. Of this 50 c.c. for analysis.

c. 44 grammes with basic acetate of lead to 200 c.c. Of filtrate 100 c.c. with sodium sulphate to 110 c.c. Of this 50 c.c. for analysis.

d. In case the solution prepared for polarization is to be used (26.048 grammes to 100 c.c.) take 46.07 c.c. of filtrate; if the solution has been made up to 110 c.c., 50.68 c.c. are necessary. Add sodium sulphate, make up to 60 c.c., and of filtrate use 50 c.c. for analysis.

e. If the sugar contains no substances which can be precipitated by basic acetate of lead, dissolve 20 grammes of the sample to 100 c.c., filter, and of filtrate use 50 c.c. for analysis.‡

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* This solution was adopted because its behavior towards invert-sugar had been most thoroughly studied, and then also because Herzfeld's table can only, under this condition, be regarded as an extension of Meissl's table.

† Zeitschrift des Vereins für Rübenzucker-industrie, November, 1885, p. 1009; Ibid., January, 1886, p. 9.

‡ It is often an advantage to make a qualitative analysis before proceeding to the quantitative determination. To do this, dissolve 10 grammes of the sample, clarify with basic acetate of lead, and heat the filtrate with 5 c.c. Fehling's solution. If invert-sugar is present, cuprous oxide will be thrown down.

Execution of the Analysis.—To 50 c.c. of the sugar solution, prepared as above, add 50 c.c. Fehling's solution (25 c.c. copper sulphate and 25 c.c. of Rochelle salt-soda solution). Over the wire gauze above the flame lay a sheet of asbestos provided with a circular opening of about 6.5 cm. diameter, on this place the flask, and arrange the burner in such a manner that about four minutes are consumed in heating the solution to the boiling point. From the time that the solution starts to boil—the moment when bubbles arise not only from the centre, but also from the sides of the vessel—continue to boil for exactly two minutes with a small flame. Then immediately remove the flask from the flame, and add 100 c.c. cold distilled water, from which the air has previously been removed by boiling.*

Then filter through an asbestos filter, wash, and reduce to metallic copper, as described under Meissl's method. The following table serves for the calculation of the percentage of invert-sugar, from the weight of the copper found.

Cu. Mgs.	Invert-Sugar. Per Cent.	Cu. Mgs.	Invert-Sugar. Per Cent.
50	0.05	185	0.76
55	0.07	190	0.79
60	0.09	195	0.82
65	0.11	200	0.85
70	0.14	205	0.88
75	0.16	210	0.90
80	0.19	215	0.93
85	0.21	220	0.96
90	0.24	225	0.99
95	0.27	230	1.02
100	0.30	235	1.05
105	0.32	240	1.07
110	0.35	245	1.10
115	0.38	250	1.13
120	0.40	255	1.16
125	0.43	260	1.19
130	0.45	265	1.21
135	0.48	270	1.24
140	0.51	275	1.27
145	0.53	280	1.30
150	0.56	285	1.33
155	0.59	290	1.36
160	0.62	295	1.38
165	0.65	300	1.41
170	0.68	305	1.44
175	0.71	310	1.47
180	0.74	315	1.50

* The object of adding the water is to prevent subsequent precipitation of cuprous oxide.

This table is based on experiments made with pure refined sugars; Herzfeld intends preparing another which is to be based on raw sugars.

This method is only available, provided the sugar sample analyzed contains besides invert-sugar no other substance which reduces Fehling's solution. Such a substance, however, often occurs in beet-sugars and is distinguished from invert-sugar by not being destroyed in boiling with caustic potash, whereas invert-sugar is destroyed by such treatment.

In dealing with such a sample, therefore, two analyses are made, one as described, and the other after previous boiling of the sugar solution with strong caustic potash.

These methods are the principal ones used to-day for the determination of invert-sugar. And yet each of them is open to criticism, excepting perhaps Soxhlet's Volumetric Method, which unfortunately requires too much time and too careful a manipulation to meet the demand of a practical method for technical purposes.

The other volumetric method (Fehling's) has been most severely attacked, and by some even condemned for various reasons which will be referred to more in detail further on.

As to gravimetric determination, Soxhlet originally denied the possibility of a correct gravimetric determination of invert-sugar in the presence of saccharose. Meissl believed it could only be resorted to for amounts not less than one per cent., and Herzfeld's method, which on its appearance was hailed with great enthusiasm, has since also proved incapable of meeting all expectations and demands.*

Bodenbender † finds as one cause at least of the difficulties encountered in all of these methods, the pertinacious use of Fehling's solution. Entirely apart from the endless confusion introduced by the varying composition of the *so-called* "Fehling's solution," and the belief held for so long that with all of these the ratio of reduction of invert-sugar to copper was as 1 : 5, Fehling's solution is affected by saccharose and can even when alone, by prolonged boiling, be caused to deposit cuprous oxide. Besides it proves unstable on keeping.

In case Fehling's solution is to be retained, Bodenbender and

* Zeitschrift des Vereins für Rübenzucker-Industrie. March, 1886, p. 201.

† Zeitschrift des Vereins für Rübenzucker-Industrie. February, 1887, p. 139.

Scheller* advocate, as the only reliable method, a duplicate copper determination, the one before, the other after the destruction of the invert-sugar. The directions are as follows:

Of the caustic potash necessary for the preparation of Fehling's solution, dissolve 40 grammes + 175 grammes Rochelle-salt to 400 c.c., and 20 grammes to 100 c.c.

I. Heat 10 grammes (50 c.c.) of the sugar clarified with basic acetate of lead to boiling. Into this put 50 c.c. Fehling's solution heated to the boiling-point. This is composed of 25 c.c. copper sulphate solution, 20 c.c. of the alkaline Rochelle-salts solution, and 5 c.c. of the caustic potash solution. Boil for exactly two minutes.

II. 10 grammes (50 c.c.) of the sugar clarified with basic acetate of lead are boiled for 10 minutes with 5 c.c. of the caustic potash solution, care being taken to replenish the water which evaporates. Then 25 c.c. copper sulphate solution + 20 c.c. of the alkaline Rochelle-salts solution are added, and the mixture boiled for two minutes more.

The amount of copper obtained under II. is subtracted from the amount found under I., and the remainder calculated to invert-sugar.

In place of Fehling's reagent Bodenbender recommends very earnestly the use of Soldaini's solution, which is to be prepared as follows: Dissolve 40 grammes of copper sulphate in water. Add a solution of 40 grammes crystallized sodium carbonate. Filter out the precipitate of basic carbonate of copper (H_2CuO_2,$CuCO_3$) and wash until no more sodium sulphate can be detected in the filtrate. Then bring the basic carbonate of copper in small portions into a hot concentrated solution of 416 grammes potassium bicarbonate, digest for ten minutes on the water-bath, pour the whole liquid into a two-litre flask, make the volume up to 1400 c.c. and heat for two hours with frequent stirring-up on the steaming water-bath. The flask is to be provided with a back-flow condenser. Filter off from any undissolved copper carbonate. The density of the solution will be about 40° Brix, equal to a specific gravity of 1.18.

The great advantages claimed by Bodenbender and Scheller for

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* Loc. cit.

Soldaini's solution are: It does not deposit cuprous oxide on boiling for some time. It is a very delicate reagent for invert-sugar.

Chemically pure saccharose affects it only after boiling for six or seven minutes over the naked flame, and only after twelve minutes heating in a salt-water bath. It is more stable than Fehling's solution.

Upon these recommendations Soldaini's solution was quite generally experimented with by the German chemists, but after a year's trial, the verdict passed upon it is, that, while the solution certainly possesses certain advantages, yet the difficulties of producing it of a homogeneous and uniform character, are so great that for the present its use as a quantitative reagent is not endorsed; its merits as a qualitative reagent, however, are not disputed. In a mixture of 10 grammes saccharose and 0.0005 invert-sugar, this reagent gave a distinct reaction.* The writer's experience with preparing it has been very satisfactory, but its stability was not found to be as great as expected.

Under existing circumstances it proves no easy task to make a proper selection of a practical working-method from among those given. If we were free to follow the precept: "Try all, retain the best," Soxhlet's volumetric method would probably prove the choice. But the proper execution of this, as already stated, calls for more time and attention than can be given in the technical laboratory where many determinations daily are required.

The question then lies between Meissl's method with Herzfeld's extension of the same whenever required, and Fehling's volumetric method as described.

To meet the requirements of practice, the method chosen must give correct results, and yield the results in the shortest time and with the least amount of skilled labor. Considering the first point, both methods are open to criticism. The principal objections urged against the volumetric method are:

a. The reducing power of invert-sugar varies with the ratio existing between it and the amount of copper liquor present;

b. after somewhat prolonged boiling in a strongly alkaline solution, saccharose also reduces Fehling's solution; †

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* Zeitschrift d. V. f. R. I., 1888, No. 391, p. 722.

† The reducing action of saccharose is to be explained by the fact that saccharose in alkaline solutions is in a short time partially transformed into invert-sugar, and

c. difficulty of distinguishing the end point of the reaction.

Chiefly on these grounds German chemists have pronounced against this method, and in favor of Meissl's.

The first objection is a valid one; the second can be met by working quickly and avoiding an excess of alkali; and the third is perfectly groundless.

Against Meissl's method—not, it is true, as by him prescribed, but as often practiced (alcohol-ether process)—must be cited, on the one hand, the danger of oxidizing the cuprous to cupric oxide on drying, and, on the other, the danger of not drying enough, and in consequence weighing retained moisture as cuprous oxide and securing results too high. The practice which some indulge in, of filtering through paper instead of asbestos, must be condemned, owing to the paper retaining varying amounts of cupric oxide from the solution.*

But the chief fault to be found with Meissl's method is the length of time which is required to carry out a determination. Counting all steps necessary, the charging of the tubes with asbestos, the weighings which must be made, the time required for filtering and drying, and finally the calculation required to figure the result, at least an hour to an hour and a half is needed. Nor is this time materially reduced by making several such determinations at once; for, whereas the time total used in drying is greatly shortened, yet the weighings and the calculations must be made for each determination separately.

A test done by the volumetric method requires but from eight to ten minutes, and as such a gain of time, as compared with the time required by the other method, proves a great advantage where many tests must be made, determinations were carried out to ascertain, in the first place, how duplicate results obtained by either method would tally, and in the second place, how results obtained on the same sample by the two methods would compare.

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furthermore is made to take part in the reducing action of any invert-sugar originally present. The extent of this action depends in the first place on the degree of alkalinity of the solution, furthermore on the time of boiling, the amount of the substance used, and the amount of invert-sugar originally present. E. Preuss, Zeitschrift d. V. f. R. I., 1888, No. 391, p. 730.

* Herzfeld, Zeitschrift des Vereins für Rübenzucker-Industrie, November, 1885, p. 1008.

Duplicate Determinations made by Volumetric Method.		*Duplicate Determinations made by Gravimetric Method.*	
6.06	5.13	2.58	9.18
6.13	5.08	2.66	9.25
15.40	2.08	5.16	4.80
15.60	2.10	5.14	4.85
6.29	2.56	4.92	8.75
6.29	2.58	4.86	8.65
3.23		6.64	6.19
2.94		6.49	6.26
5.26		6.04	
5 26		6.02	

These duplicate tests were made in part by the same, in part by different operators, and certainly prove that the results yielded by *either* method are constant. To determine how results yielded by the two methods would agree, the following determinations were made:

Percentage Invert-Sugar.			
Sample.	Volumetric.	Gravimetric.	Difference.
Refined Sugar.	6.25	6.38	0 13
Refined Sugar.	9.52	9.55	0.03
Refined Sugar.	10.00	10.13	0.13
Refined Sugar.	5 02	4.80	0.22
Refined Sugar.	8.13	7.87	0.26
Refined Sugar.	9.00	8.75	0 25
Domestic Molasses Sugar.	3.23	3.18	0.05
Pernambuco Sugar.	4.87	4.83	0.04
Barrel Syrup.	27.77	28.04	0.27

The greatest difference will be found in the case of a barrel syrup, 0.27 per cent., a difference not as great as found in making a duplicate gravimetric test on this sample.

That the danger chiefly feared in this method, *i.e.*, the reduction of the Fehling's solution by the saccharose, is not as great as is generally represented, is illustrated by the following.

Six samples of beet-sugar which on testing with methyl-blue were found to contain invert-sugar, were submitted to quantitative analysis by Herzfeld's method. There were reduced by:

No. 1, ... 17 mgrs. copper
" 2, ... 43 " "
" 3, ... 15 " "
" 4, ... 27 " "
" 5, ... 15 " "
" 6, ... 20 " "

50 mgrs. copper correspond to 0.05 per cent. invert-sugar, so in all of these samples the amount of invert-sugar was less than this, still some was present.

Forty grammes of each sugar were dissolved up to 100 c.c. and a volumetric analysis made. *Not in a single instance* was even a trace of cuprous oxide precipitated, although from 75 to 86 c.c. of the sugar solutions were used, and the regular course of analysis followed.

It is the writer's opinion, borne out by several years' experience in practice, that Fehling's method, although by no means above criticism, is sufficiently reliable and exact to answer all demands of routine work, and that it possesses over Meissl's gravimetric method the great advantage of speed of execution, six to eight determinations being easily made by the volumetric, in the time required for the completion of one test by the gravimetric method.

THE INSTRUCTION IN ARCHITECTURE AT THE SCHOOL OF MINES.

A PAPER READ BEFORE THE ALUMNI ASSOCIATION OF COLUMBIA COLLEGE, JUNE 12, 1888.

IT is within only a few years that Architecture, though the oldest of the Arts, has, in this country, obtained recognition as a profession among scholars and in places of learning. Yet there can hardly have been any question as to its importance. To an animal like man, that cannot live out of doors, where if night and winter do not kill him noontide and summer will, shelter is as necessary as food. Buildings are indispensable to him. The history of civilization is written all over the world with them, and coeval and coextensive with the useful art of good building is the decorative art of fine building—the application to these structures of that notion of perfection which brings every one of the useful arts sooner or later into the service of the ideal. Thus thinking, the most useful of arts to a thinking creature, flowers into poetry; speech into eloquence, in prose and verse; walking into the dance; drawing, the language of form, into pictures and sculpture. So is it with all manufactures: weaving gives us brocades and laces,

tartans and damasks; pottery, majolica and faience. It is a long way from these petty fabrics to temples and cathedrals, but the principle is the same; it is through the hunger of the soul for perfection that from mere building architecture is born.

Among all the works of industrial art, the works of the architect stand conspicuous in space and in time; they appeal to the imagination as do no others. The poets, who are the spokesmen for mankind, do not scruple to name the cloud-capped towers, the gorgeous palaces, the solemn temples, in the same breath with the great globe itself. Buildings form the scenery of civilization; they make the background of every historical picture. Moreover, while paintings and statues are the work of this man or that, a great building is a social enterprise; the work is carried on by an organized army of workmen, of every rank—laborers, carpenters, masons, hewers and carvers in stone and wood, cunning artificers in iron, lead, and glass, painters and sculptors, draughtsmen, supervisors, and at last the architect to devise, direct, and control.

In other times, the architect grew in his place, as a great tree grows in the wood, the quiet working of natural forces giving just ascendency to the more vigorous shoots, until some strenuous sapling overtops the rest, and, once in the free air, spreads his branches and shoots towards the sky. So, out of the rank and file of masons and carvers seem to have sprung the master-builders of all ages, whose works continue to them a nameless fame. But these conditions are not ours. If, now that the whole land is laid waste by cultivation, you would have the trees you want, you must establish nurseries, and plant and water, with all the artificial appliances of science and art. If, in modern society, you want architects, you must train them up.

Half a dozen years ago, accordingly, your own trustees, stimulated thereto by the zeal and munificence of some of their own number, determined to add a department of Architecture to their School of Mines. For the last three or four years the course has been fully organized in a tentative and more or less experimental way. The first graduates took their degree four years ago. Eight will graduate to-morrow, making twenty-six in all. It seemed to your committee high time that you knew what was going on, and I have ventured to accept their invitation to tell you what we are doing and trying to do.

Meanwhile, beginning with one or two students, six years ago, we have this year had nearly sixty, and, instead of occupying one corner of the miners' drawing-room, we have seven rooms of our own.

In setting this instruction on foot the first question, of course, was what these classes should be taught, and behind this lay a previous question, what an architect should know. To this question a stiff-necked and censorious generation has a prompt and ready answer. You all of you doubtless understand that an architect should know everything about everything, and have all his information at the tip of his tongue. This expectation is one of the thorns with which our rose-tree is beset. It is more reasonable to reply that an architect, like any other well-educated man, should know a little of many things, and one thing well, and this brings the inquiry to this interesting point: What are the things, within the range of his own special studies, that an architect needs to know all about, so as to be on easy and familiar terms with them? After that, what is the one thing among them that an architect is bound to know well—to know, that is to say, better than anybody else knows it. Then comes the practical question for us here, which of all these topics may reasonably be attempted in three or four years of schooling, and what may safely be left for the school of experience, and for that kind of modified apprenticeship which consists of spending half a dozen years in office work as a draughtsman.

There are, of course, architects and architects. But the kind of architect we have in mind, the only kind who has any place in an institution of learning, is a cultivated and well-educated man, capable of sympathizing with the best aspirations of his best clients.

In the first place he should have some sufficient acquaintance with the mechanical trades, the arts of the mason, carpenter, plumber, plasterer, tinman, blacksmith, painter, glazier, and decorator, not to speak of the carver and sculptor. Then come the branches of engineering and mechanics, statics, strength of materials, the theory of arches, beams, and columns, flow of air and water, ventilation and drainage, and all the mathematics that attend the quantitative treatment of these things. Then business matters, contracts, estimates, specifications, inspection of work, settling of accounts, adjustment of responsibility, and useful maxims for de-

tecting or outwitting a thief. Then capacities and attainments in matters of art. First, good taste, the passive principle, that is to say, a natural and cultivated sensibility, the capacity for recognizing and enjoying a good thing when one meets it. Then artistic skill, the ability to produce artistic work, that is to say, to give to what one does the charm of form, that active principle which, as has been said, makes everything a work of art, adorning whatever it touches. Then erudition, the knowledge that distinguishes the connoisseur, but carried to the point of a technical acquaintance with historical precedents and the shibboleths of styles; and, finally, the art, mystery, and manual occupation of draughtsmanship, in the practice of which the architect has principles and methods of his own.

All these things an architect needs to understand, so as to be, in so far as his natural gifts permit, a sound and decided judge of work, so as to ask intelligent questions, detect unintelligent answers, and make sensible suggestions; so as to have opinions of his own, and to be able to express and defend them efficiently by pen or pencil.

Finally, or indeed first of all, for this is the architect's own function, which nobody can discharge for him, he must have skill in composition, in the arrangement of parts, in plan and in elevation, so as to make them comport with one another, and out of given conditions, however diverse, contradictory, and seemingly irreconcilable, to produce a simple, natural, and harmonious whole.

If these things are so, as they are, how may young men of eighteen best spend three or four years at school so as to fit themselves for this career? That is the question we are engaged in solving.

It is practically a new question, for architectural education in France and Germany, like university education in those countries, is so much under government influence, and architects, like the graduates of universities, are so largely dependent upon government patronage for success, that few practical lessons can be drawn by us from their schools. The conditions are too diverse. In England we might expect to find more congenial models, but for reasons easily understood the English architects are rather looking to us for example than we to them. We have, then, not only to run our factory, but to invent our machinery. We have to lay out our subjects for ourselves, write our own text-books or go without, and learn

by the successes and mistakes of each year what to do and what not to do in the next. This makes progress slow but safe, and I believe that our conclusions are sound.

In the first place, we believe that we are bound to turn out liberally educated men. So far as breadth and variety of training goes we can hardly fail to do so, for it is a commonplace to say that, next to going to college, studying architecture is the most generous discipline a young man can find. But it is not safe to trust entirely to the liberal quality of the strictly professional studies. We must see that our men have a working knowledge of some modern languages besides their own, and that they have sufficient discipline in the use of their own language to employ it with efficiency and correctness. We must see that they know how to use books, and can give a good account of what is in them.

In the next place it is plain that, in order to cover all this ground at all, we must be content in many things, if not in all, merely to open the gates of knowledge, to point the road, to put the traveller in good case for the march, and to equip him with weapons to bring down any game he meets by the way—not to provide him at the start with all he will ever need. This simplifies our task. All we really have to do with is, in most things, the elements of knowledge. But these are elemental; all the principles are contained in them. But even with this, so long is art and so short the time at command, it is needful to save the student's time and labor to the utmost; not, indeed, by doing his studying for him or giving him only the results of other people's work, but, while compelling him to discover things for himself, so to organize and arrange the objects of study that he may promptly find what he seeks.

To this end it is desirable, if possible, so to arrange the different topics that they shall be made mutually to illustrate each other, a thing difficult to accomplish in general courses of liberal studies, though if it could be done it would seem to solve the problem of university education, reconciling the claims of general and special studies in a single scheme. If the student of philosophy, for example, could be made to study his Plato and Cicero in the original texts, to read the mathematical speculations of Leibnitz and Descartes in German and French, to illustrate the history of philosophy by other historical studies, and to examine the applica-

tion of logic, and of the inductive and deductive systems, to the natural and exact sciences, to biology and political economy, he would be none the less a specialist, and would at the same time be pursuing a course of liberal study in Greek, Latin, German, French, mathematics, sociology and natural history. But this, while it may be difficult to provide for in a college, is comparatively easy in a professional school. How to bring this about here, so as to bring the four or five different branches which constitute our curriculum into relations of mutual assistance, is our constant study. Already we have made some progress towards its solution.

The first of these distinctive studies is draughtsmanship, for drawing is the natural language in which to express ideas of form. In this, as I have said, architects have methods of their own, midway between those of the painter and those of the civil-engineer, combining the accurate thinking and quantitative determinations of mechanical drawing with the lightness of touch and artistic quality of the studio. Even in free-hand sketching and in drawing from nature an architect remembers his geometry and perspective, bringing science into the service of art. When, on the other hand, he takes out his T-square and compasses his right hand does not forget its cunning, but brings the touch of art to supplement and embellish this mechanical performance. We discard, moreover, the clumsy apparatus of the drawing-schools, the charcoal and crayons, bread, stumps, and other dirty appliances, and remembering that the pencil is the architect's weapon, learn to do what we can with that, going straight to the heart of the matter. Indeed, all the principles of drawing and much skill in the practice of it can thus be acquired in the time that it takes to learn to handle less simple materials. These can be mastered at short notice when they are needed to express what the pencil cannot convey.

Next to the pencil the pen and the brush are the most to our purpose, and in the use of these our men are constantly practiced, especially of the brush. For in this, as in other things, it is the function of the school to give them what they will not get elsewhere, and as pen-drawing is practiced in every office in the country they must learn the use of the brush here or not at all. Not to be taught it at all is to be defrauded of half their birthright.

Our portfolios are full of excellent examples showing how these materials are handled by skilful masters. These we use, however,

very sparingly for making copies in *fac-simile*. Indeed, to make a copy in *fac-simile* is almost an impossible achievement. It taxes the powers even of the skilled practitioner, and it is hardly fair to set the beginner to this hard task, as is so often done, and thus to doom him beforehand to failure and discouragement. Besides, it is almost impossible that he should not, in his anxiety to reproduce details of manipulation, fall into a narrow and cramped method, both of thinking and of working, and lose not only the main spirit and movement of the whole composition, but the spirit and movement of the very handling to which they are sacrificed. We find it accordingly an excellent method to practice *fac-simile* work only piece-meal and in details, as an elementary study of manipulation pure and simple, and to pass on as soon as possible to exercises in which a drawing executed in one way is copied in another, lithographs and pencil-work copied with the brush, brush-work and photographs with pencil or pen. This is as different from the other as translating is from transcribing, and like translating, while it promotes a fuller comprehension of both mediums of expression, it at the same time directs attention from the language to the thought behind it, from the character of the representation to the characteristics of the object represented.

It is practicable to push this principle a step further, and by copying water colors in black and white and oil colors in water color and, finally, making colored sketches from photographs and engravings, to prepare the way by easy stages for working direct from nature. This practices the mind as well as the hand and eye, and converts what too often degenerates into a dull, mechanical exercise into an intellectual operation. At the same time it relieves the practice of copying "from the flat" of most of the objections that are fairly brought against it. A chief part of the advantage of drawing "from the round" lies not in the fact that the lights and shades on casts and vases are real while in drawings and lithographs they are only simulated, but in the fact that in drawing from the object one has to devise his own manipulations, thinking out a course for himself, while in copying a drawing he has little choice but to step in the very footsteps of his predecessor.

Into the study of outline drawing, too, in which an architectural draughtsman of all others needs a quick eye and a firm hand, we try to bring as much head-work as possible, so that it too may count as an intellectual exercise, and thought as well as feeling

may go into the work. Hence we encourage the student to take definite cognizance of all the facts he can discover in his original, and to bear them in mind in making his copy. Every additional idea is one more precaution against error, and one more guaranty that the spirit and character of the original shall be conveyed to the copy.

For the study of form and for practice in outline drawing, architects make great use also of the despised process of tracing, for if intelligently pursued it gives great steadiness and freedom of hand, at the same time that it allows the student to accumulate with but little expenditure of time and labor invaluable stores of useful memoranda. The books full of tracings in which our young men carry away from the school the rich gleanings of our collections are among their most cherished possessions.

Besides the stated exercises in drawing, which occupy two or three hours a day during term-time, it is the rule that each student shall bring in a hundred sketches at the close of the summer vacation, or about one a day, large or small. This has proved an admirable exercise, producing a large amount and great variety of work, much of it of marked individuality.

In the study of perspective and of shades and shadows also, our students are set to special exercises, especially adapted to their needs. In the matter of shadows, indeed, a great economy is taught them. Since in architectural drawings the light is always supposed to fall at the same angle, and since architectural forms mainly consist of certain geometrical solids, variously combined, it follows that the same problems will constantly recur, and that if the forms of the most common shadows are once learned, as matters of fact, they never need be worked out again. This is not the method of the text-books or indeed of the profession, but we find great profit in pursuing the subject from this labor-saving point of view.

The architectural members into which these geometrical forms are habitually combined—columns and cornices, pediments and pedestals, arches, domes and vaults—are all taken up and studied in the same way, simple rules for drawing them out being learned, once for all. This is the subject set down in our programme as the Elements of Architecture. It occupies two hours a week of lecture and recitation in the second year, one or two afternoons

being given to the drawing out of the plates, and as many more to the preparation of a very instructive series of drawings, "in illustration of the elements," in which doors and windows and other features are drawn out and the shadows cast on a large scale, and, at last, whole buildings combining these details. To draw buildings from memory and from description is the next thing, an exercise impossible without these exact attainments. Finally, we have found it equally entertaining and profitable to make each man in the class write a detailed account of some building, from a print or photograph, and then, changing about, for each to make a drawing according to his friend's description.

It is surprising to see how near to the original some of the results have come, and equally so to find how wide of the mark some of them have fallen.

These exercises prepare the way for those in original design, exercises intended to develop the faculties of invention and arrangement, the practice of which is, as I have been insisting, the architect's distinctive task. It is to this that all his other studies lead up, his success in this is the test of their efficiency. These we introduce by giving a plan or elevation of a building, as, for example, of a Roman villa, and requiring the student to devise the second story plan, and the rear, or side elevation. Next time, we give a plan alone, and require elevations to be invented for it. Then the plan is only described more or less in detail, and so on until merely general conditions are given, and the design is entirely the student's own. The working out of these schemes under daily criticism and correction, is as interesting and instructive as anything can be, aided as it is by a comparison of the whole when all are done, and judgment is pronounced upon their merits and defects. But it is hardly necessary to say anything in the way of praise or blame; when they are hung side by side they cry out against each other. It is indeed itself a liberal education in design to see how many ways there are of doing the same thing; how one is in general as good as another, and yet, generally, that some one is sure to be better by far than any.

These compositions are all made in some form of what are called the classic styles and among the elements, studied in preparation for these exercises, are the so-called Five Orders and other details of these styles. There is not time, in school, to acquire a working familiarity with more than one set of historical traditions, and there

can be no question, to my mind, that if a single style or group of styles is to be selected for such familiarity it should be these. As mere matter of information, indeed, the Greek and Roman styles are more important than any others on account of their unique historical position, all previous styles leading up to them, all later being derived from them. Without this knowledge the history of architecture is unintelligible. Moreover, in the study of the general principles that are common to all styles, they have great practical advantages for educational purposes. The comparatively narrow limits within which their details vary make it possible to require of students a precision and correctness of execution which is of the greatest disciplinary value and which cannot be exacted in the study of styles in which the minor as well as the major elements of design are governed only by general principles, by local or temporary considerations, or by personal taste and feeling. At the same time these styles are, in all the more important elements of composition, singularly flexible, as is abundantly witnessed by the whole course of their history.

The detailed criticism of these designs serves as a sort of lecture upon composition and planning, and besides this, there are from week to week more formal discourses under the head of the theory of architecture, upon the received theories of beauty and proportion, in form and color, given, mainly, with a view to show how little value there is in speculations on these subjects. But it is worth while to spend a certain amount of time upon them, nevertheless, if only as a *prophylactic*, as the doctors say, to prevent these young men from being run away with by such fancies at a later day. Moreover, they afford a glimpse of mental science in considering the phenomena of vision and of the muscular sensibility, and the doctrines of sensation and perception with which they are bound up.

When these topics run out, the time given them is taken up by lectures upon the arts auxiliary to architecture, pottery, tiles, stained glass, fresco, mosaic, and enamels.

In the School of Fine Arts, in Paris, exercises in design such as I have described, *projets* given out from month to month all the year round, form the chief work of the school. There are excellent examples of such work hanging framed upon our walls. At the Institute of Technology, in Boston, also, we followed as closely

as we could the Paris example, being greatly aided in doing so by the fact that a considerable portion of our students were special students, able to give pretty much all their time to this work, and that a chief part of these were young men who had already, by work in offices, had an experience which stood them in place of the preparatory studies exacted for entrance into the school in Paris. This system has been continued by my successors with brilliant success. But, though design is the main thing, it is not the only thing, neither can it be taken up to advantage without adequate preparation. The young men we have here are mostly entirely new to the subject, and it is useless to set them to combining and arranging ideas they have never acquired. Much of their time is accordingly best spent in the elementary and disciplinary exercises of draughtsmanship of which I have spoken. When we succeed in getting this work accomplished somewhat earlier in the course than at present, we may hope to have time, and to have sufficient preparation, for more extensive work in original composition.

Still, the work done by our own students in this field already is by no means unimportant. In the first part of the present year, in addition to the preparatory exercises just mentioned, the third- and fourth-year classes, working together, presented designs for—

1. The pedestal to a statue, the photograph of the statue being given
2. The same revised and put into perspective.
3. A portico in a park.
4. A small museum.
5. A tower and belfry.
6. A seminary, in two stories, and chapel.
7. A wayside chapel and pulpit.
8. A *Chateau d'eau.*

In this last, which was much the most elaborate and extensive of any, the class worked out with much care an interesting scheme for the decoration of the Reservoir Park, between Fortieth Street and Forty-second Street, by building against the back of the reservoir a monumental fountain with cascades discharging into a basin below all the surplus water brought into the city by the aqueduct.

The excellent work thus excellently begun might have been carried farther if we had not deliberately abandoned it for other

tasks equally important. The munificence of one of the Trustees, —if I were sure that Mr. Augustus Schermerhorn were not here, I should almost be tempted to mention his name—has provided us with a collection of books and photographs such as no other school possesses. But it is easier to make collections than to make use of them, and I have found, somewhat to my dismay, that the better I made my lectures upon architectural history, the less inclination, the less need, the students found for consulting these authorities. Seven hundred books and twelve thousand photographs stood neglected upon the shelves. This state of things demanded a heroic remedy. The only cure seemed to be to lecture as badly as I knew how—a field in which nobody can tell what he can do till he tries. Instead of thirty or forty careful discourses on Gothic architecture, occupying the whole year, I confined myself to ten or a dozen a year, running over the subject in the most superficial manner. As the time for the examination approached, since it was hardly fair to expect the class to know more than they had been taught, I divided among them the topics on which I had touched, giving them a month to study them up and to prepare to write out, in the form of an examination paper, the result of their studies. At the end of the month they presented a dozen excellent essays, full of new matter gleaned from the books, upon vaultings, tracery, mouldings, carving, sculpture, towers and spires, pinnacles and buttresses, etc., etc. The next term we reviewed the ground gone over, taking a week for each topic and making the essays prepared for the examination the point of departure and basis for further research. The books and photographs were divided into a dozen parcels, one of which was assigned each week to each student to report upon. The next week they changed piles and studied up and reported upon another topic. By the end of the twelfth week the twelve topics had been most thoroughly discussed, every student had been through every book and looked at every photograph, and the problem of bringing the collections into use had found a triumphant solution.

But, as I have said, drawing is the natural language for the expression of facts of form, and if these exercises were to have their full value, the weekly reports must be largely in the shape of drawings, tracings, and sketches. For this second half the year the exercises in design were accordingly abandoned, and obvious as is the loss, there is but one opinion, I believe, that the gains are

greater. For the practice of design is the main business of an architect's life, and what is not done here may be done elsewhere by and by. But such a chance to study photographs and books for weeks together is elsewhere hardly to be found.

Still, even during this half the year and in the midst of these historical studies, the practice of original design is not entirely given up. On the contrary, advantage is taken of this intimate study of various styles to try the experiment of working with other details than those which our *Elements* have made familiar. This we call historical design, taking up the problems of ancient days before their solution has been reached in the course of our studies, and letting the class solve them for themselves. When, for example, the construction of the four-part vault had been explained, the class were given the problem of carrying a vaulted aisle round a semi-circular or polygonal apse. It was satisfactory to find that in the course of a couple of hours' study the class managed to work out, without assistance, the five solutions of this problem which, in the Middle Ages, it took two hundred years to develop. Exercises in designing tracery, and even in the profiling of mouldings, were almost equally successful.

This last year we have followed the same course in regard to modern architecture, taking up in turn domes, towers, arcades, ceilings, capitals, cornices, etc., etc.

The younger class, meanwhile, have pursued the study of ancient history more or less after the same manner.

At the same time my assistant, Mr. Hamlin, has given weekly lectures upon the history of ornament, the class again making sketches and drawings in illustration of the topics brought up. But the chief return for his labor has come in the form of careful reports of his lectures, written out by the members of the class in turn and printed off by them upon the *Hectograph* for each other's use. This has done something towards supplying that practice in writing the English language, which a chief part of our students greatly need.

The modern languages it is more difficult to provide for, for though a minimum of acquaintance with both French and German is exacted for admission to the school, this has generally proved too little to be of any practical service in our daily work. To

remedy this we have this year tried the experiment of reading with the class a French text-book, for which we were able to command two hours a week. This plan was not, however, without certain practical difficulties. It was plain that if the lessons were long they would not be learned, and the study would be too superficial to be of real benefit, while if the lessons were short we should never get through the book, and, besides, the exercises would be intolerably dull and uninteresting. The only escape from this dilemma seemed to lie in giving each student a different page to learn, a device which has worked so well that one cannot but feel surprised that it is not more commonly adopted. Notice was given that, at the end of the term, the class would be examined upon the whole book. Each student accordingly paid close attention to the work of the others, noting upon the margin of his book the meanings of unfamiliar words—making, in fact, a careful study of it in the class. As every sentence was read in French, in English, and again in French, there was plenty of time for the class to know it well. In this way they read the whole of Maspéro's *Archéologie Egyptienne*, at the rate of twelve or fifteen pages a week, with interest and enjoyment, and made marked progress in command of the language. At first only half a dozen, out of twenty-four or five, made even a passable performance. After six months hardly any failed to give both the French and the translation with fair precision, and almost all succeeded very well in translating from French to English, and even from English back into French, without looking in the book.

There remain next to be considered the scientific branches—the mathematics, mechanics, and engineering—in which a scientific study of construction is comprised. These studies are taken by our students along with the students of engineering, but they occupy a very different place in an architect's equipment from what they do in an engineer's. The work of the engineer is mainly based on mathematics, and his daily tasks illustrate and are illustrated by the principles laid down in the text-books. A purely theoretical acquaintance with them thus presently becomes practical knowledge. An architect, on the other hand, is mainly occupied with other things, and it is only occasionally, and generally long after his school days are over, that he has need to use his mathematics, and then only in its simplest applications. The

training he requires at school then is much less extensive than that proper for the engineer, but so far as it goes it should be as practical as possible, and the main principles and methods need to be made so familiar and to be so thoroughly assimilated that they can never be forgotten. An architect does not need to study such long and hard lessons as the engineer, but it is more necessary that he should learn them well while at school, for it is in general his only chance of learning them at all.

To adjust the relations of these and other scientific studies to the strictly architectural work is a matter of some difficulty, but it will be worth all the trouble it costs if these relations can be made more intimate. An attempt is already making to abridge the time given to mathematics and mechanics without impairing its efficiency for our special needs. To this end we have undertaken to give much less time than is given by the students in engineering to the subjects of analytical geometry and the calculus and their applications, restricting the ground gone over to what is absolutely necessary to an understanding of the limited amount of civil engineering that an architect requires, and plentifully illustrating the ground we do go over by means of graphical exercises, as the tastes or habits of our own students make it easy to do.

The time gained in this way is well spent in giving more attention than has hitherto been possible to practical affairs. It is not the function of a school to teach what can be learned as well or better in architects' offices, and there is much in architecture, as in every profession, that only the slow and sometimes expensive school of experience can teach. But something may be done in advance to shorten the time and to lessen the chances of misadventure. Moreover, the student can, at this distance, get a more comprehensive view of the field of practical affairs than when brought into actual contact with their details, and may well give a few hours every week to the general considerations which control and to the facts that underlie the daily course of office procedure. Instruction in estimating and the taking out of quantities, and lectures upon business relations and legal obligations and upon the conduct of competitions, are included in the course; a comprehensive form of specification is read over and explained, and is copied by the students; and carefully-prepared examples of working drawings are given them to trace or draw out. An illustrative

collection of materials and appliances is in course of formation. A proper architectural laboratory, in which the class might acquire a personal acquaintance with mortars, cements, paints, varnishes, etc., the establishment of which was first in my mind when I came here half a dozen years ago, has so far proved impracticable, chiefly because the space devoted to it has, in the unexpected affluence of students, been given up to other uses.

But the same public spirit and zeal for everything that can benefit the profession that some years ago led Dr. Auchmuty to establish his trade schools in Ninetieth Street has now led him to put at our disposal, if we can use them, the ample appliances they contain for the illustration and explanation of almost every building art, and we hope presently to be able to avail ourselves of them.

But it is not my purpose to delay you with any enumeration of our hopes and expectations. If commensurate with our opportunities they would take long to recite, for more favorable opportunity for establishing a school of architecture could not well be found. The field is large and free; we are unhampered by traditions or prejudices; what has been done is so much as to encourage us, so little as to stimulate us to fresh endeavor. Whatever is done has the support and good-will of the profession, and there is every prospect that promising material, of which there is an abundance, will, increasingly, find its way to our doors.

ROSENBUSCH'S MICROSCOPIC PHYSIOGRAPHY OF THE MASSIVE ROCKS.*

(Continued from page 374.)

CLASS III.—EFFUSIVE ROCKS.

THE effusive rocks of which we meet the normal types in the geological form of sheets and streams are, in character, superficial. They show us in solid form those parts of the telluric eruptive masses which come up to the surface through fissures in the

* Mikroskopische Physiographie der Massigen Gesteine, von H. Rosenbusch. Stuttgart, 1887. Pp 887. Pl. vi. Translated for SCHOOL OF MINES QUARTERLY by F. J. H. Merrill.

earth's crust, and then spread themselves over parts of it. Now, since there appears to be no ground for assuming that the eruptive magmas which have taken geological form in the plutonic and volcanic rocks, were originally different, we should believe that for every plutonic rock there is a volcanic rock equivalent to it chemically and mineralogically, and which essentially differs only in its structure in accordance with the changed conditions of solidification. This, however, is the case only to a limited extent. There are, indeed, volcanic rocks which, according to their mineral and chemical composition, are quite parallel to the granites, syenites, etc. An exact comparison, however, of the quartz-porphyries and liparites with the granites, the quartzless-porphyries and trachytes with the syenites, of the phonolites with the elæolite-syenites, of the andesites with the diorites, etc., teaches that, in general, a given volcanic rock always differs from the corresponding plutonic rock by a higher content of silica and oxides of the monad metals, and through a lower content of oxides of the dyad metals. We may express this briefly by saying that volcanic rock is always more acid than the equivalent plutonic rock, consequently, with a holocrystalline development of both, the volcanic rock should be, and is, specifically lighter than the equivalent plutonic rock. This difference in the density may naturally be increased greatly when the volcanic rock does not attain holocrystalline development, but has a hypocrystalline structure.

The cause of this constantly recurring chemical difference, which naturally finds its mineral expression in the smaller quantity of non-feldspathic components, and in the predominance of the alkali-feldspars over the lime-soda feldspars, is not in any way explained by the hypothesis that the volcanic rocks on their way to the earth's surface have been chemically altered in the sense used above. The composition of the upper portion of the earth's crust is opposed to this. The relative difference, however, finds a natural explanation when we assume that a liquation or separation according to specific gravity, took place in the eruptive magmas during their slow rise through the fissures and while they remained in them; as in a salt solution which remains at rest for a long time in a high beaker. Consequently those portions of an eruptive magma which develop as plutonic rocks must be somewhat more basic, poorer in alkalies, and richer in alkaline earths and iron

than those portions which become effusive rocks upon the earth's surface.

As it was structurally characteristic of the normal plutonic rocks, that each of their components attained a crystalline development during but one continuous period of formation, so it is characteristic of the normally developed volcanic rocks that one or more of their components separated out of the eruptive magma in at least two distinct periods of time; wherefore the older generation is distinguished from the younger generation or generations chiefly through complete idiomorphism and larger dimensions. This relation leads evidently in the most pregnant cases to a contrast, usually macroscopical, of *disseminated crystals* (individuals of the older generations of mineral structures) and *ground mass* (aggregate of the products of crystallization of the younger generations together with solidified remnants) from crystallization. Those structural forms which are based upon the above-mentioned recurrence of similar or identical minerals will be designated as *porphyritic structures.* They are characteristic of normal volcanic rocks. The volcanic rocks, therefore, have been directly designated as porphyritic in the same manner that the terms plutonic rocks and granular, or more strictly hypidiomorphic-granular rocks may be regarded as synonyms.

The development of porphyritic structure in the volcanic rocks is the necessary consequence of the conditions of their formation. Their development is not purely intratelluric like that of the plutonic rocks. In their case a period of effusion follows upon the intratelluric period, and we may, with a probability bordering on full certainty, state that the crystallization of the older generation of components (disseminated crystals) was completed essentially during the intratelluric period, and that of the younger generation and the ultimate solidification (ground mass) was completed during the effusion period. The truth of this proposition especially follows, independent of the study of solid rocks, from the study of momentarily cooled portions of flowing masses of lava. A lava at the moment of its effusion is not simply a molten liquid but a molten fluid, in which are floating greater or smaller quantities of separated minerals with idiomorphous boundaries. The conditions under which the crystalline separation of the older generations of constituents are quite different from the formative conditions of the "ground mass." With the exit of the eruptive magma

upon the surface of the earth the chemical composition changes, since with decreasing pressure the water content rapidly escapes, and the lava, through loss of water, suddenly becomes much more acid. Simultaneously with the effusion of the eruptive magma, however, begins an accelerated diminution of temperature, and consequently a more or less important diminution of molecular activity. These relations influence the rock-development in two directions. On the one hand many combinations which have separated in the interior of the earth become unstable through the sudden and great increase in the acidity of the eruptive magma, and in consequence undergo absorption, while newer compounds separate out, which correspond to the changed conditions. On the other hand, beside the laws of crystallization affecting mixed solutions, the quickly falling temperature and the solubility dependent thereon must have a conditioning influence in the process of the rock solidification upon those crystalline separations existing during the period of effusion.

There is, therefore, a sort of hiatus in the rock-development between the formation of the disseminated crystals which have separated within the earth and the more or less crystalline solidification of the ground-mass. It would, consequently, be rather incorrect if one should wish to draw a sharp line between the quantity of separated salts present at the moment of eruption and the fluid "mother liquor," judging by the relative quantity of disseminated crystals and ground-mass. Many phenomena, on the contrary, indicate that the crystals developed within the earth can, and really do, grow larger in the remaining "mother liquor" during the period of the effusion of the rock. Indeed, the holocrystalline, granular structure, sometimes hypidiomorphic, sometimes panidiomorphic, in the central portions of volcanic rocks, which is frequently, and, indeed, essentially conditioned by the slow cooling, may be explained with greater probability by the continuous increase in size of the disseminated crystals.

The stated relations of the development of the volcanic rocks, condition as well a multitude of greater and more characteristic differences between these and the plutonic rocks, such as the frequency of the association with them of loose or secondarily solidified ejecta (tuffs), the wide distribution of fluidal phenomena and the occasional peripheral cellular character which is designated as scoriaceous, vesicular, etc., or as amygdaloidal structure. The

development in the eruptive rocks of rounded, smooth-walled cavities, which are caused by the escape of gases, presupposes without doubt the presence of a plastic, fused substance.

If, however, the porphyritic structure must be ascribed as essential to all normal volcanic rocks alike, in contradistinction to the granular structure of the plutonic rocks, the character of this structure is, nevertheless, a very variable one. Only those relations will be discussed here which appear more or less in all the families of volcanic rocks, peculiarities limited to one or a few families will be traced out in their proper place.

In the next place, the relative quantity of disseminated crystals [*Einsprenglingen*] (separated minerals of the older generations) and ground-mass (younger generations and amorphous remnants of crystallization) varies between very wide limits. These older crystals, as well as the ground-mass, not only in different rocks but in different parts of the same rock-mass, may diminish to nothing. In consequence, on the one hand, the passage into granular structure may be completed; the opposite extreme rarely occurs, and leads in part to a granular structure (through holocrystalline development), in part to glassy forms of rocks.

Since the volcanic rocks are composed of the same minerals as the plutonic rocks, their components may be arranged in the same four groups:

1. Ores and accessory components, Magnetite, Ilmenite, Hematite, Apatite, Zircon, Titanite, etc.

2. Iron-magnesia silicates, Olivine, Mica, Amphibole, Pyroxene.

3. Feldspathic, lime-alkali bearing components, Feldspars proper, Nepheline, Leucite, Melilite, Sodalite, Haüyne.

4. Free Silica.

So far as these minerals appear among the crystals of the older generations, the sequence is everywhere and always the same as that given above. If we now suppose a volcanic rock of such chemical composition that all four of the above groups *might* be formed among the earlier separations, it must be emphasized that each one of these groups does not always appear among the older or intratelluric generations.

Much more frequently one, or several, of these groups are wanting, and in regard to this the rule prevails, almost without exception, that *an earlier group is never wanting when a later is present.* This is explained by the fact that the effusion of the rock in one

case occurred earlier with reference to its intratelluric development than in another case, so that, in the latter, older mineral forms would be present which are lacking in the first.

Although phenomena of the magmatic resorption of older compounds which have become unstable may be recognized here and there in the plutonic rocks in spite of the greater uniformity of their structural conditions, such appearances must be expected to appear more frequently in connection with the more explosive development of the volcanic rocks, as well as their sudden loss of water in the period of eruption. Experience fully confirms this. Such resorption phenomena may often be observed, especially in the second and fourth of the above-named groups of components, but they never fail in the other two groups, although in them they are, on the whole, much less frequent.

The minerals already crystallized out in the eruptive magma are subjected, during the eruption and the outflow of the same over the earth's surface, to important mechanical influences, which will cause a rupture of these crystals more easily the more elongated their form and the more viscous the mother liquor. These ruptures distinguish themselves from those mechanical deformations produced by the pressure of the earth's crust in that they never present the character of having been crushed, and consequently never lead to superficial or total disintegration, and in their appearance do not change with their position; hence, also, for example, they produce no sinuous extinctions. Elastic minerals, as, for example, mica crystals, may naturally go through the processes of eruption, undergo bending and cracking, which can in no way be distinguished in certain stages from the deformations produced by mountain-making pressure. The idiomorphism of the disseminated minerals is, in general, very perfect, aside from the exceptions already named.

It may be stated, as the result of experience, that the degree of idiomorphism of the disseminated minerals varies in inverse ratio with the crystalline development of the ground mass. This fact is easily explained if we consider that an incomplete crystalline development of the ground-mass presupposes a rapid congelation of the "mother liquor." Consequently the period of magmatic resorption, and, therefore, of chemical deformation (corrosion), is shortened, and at the same time is removed the possibility of a

longer process of growth for the first generation of crystals in which a distortion of form might occur.

The most essential differences in the porphyritic structure are conditioned by the formation of the ground-mass. During the solidification of the latter two agencies openly oppose each other; the chemical affinity which leads to the separation of crystalline compounds and the rapid loss of temperature leading to amorphous solidification. If we imagine this first agency to be very great in comparison with the second, the fluid "mother liquor" still present during the outflow will be broken up into crystalline compounds alone, and we have a *holocrystalline ground-mass.* The structure of the volcanic rock is now called *holocrystalline porphyritic.* If, on the contrary, the cooling after the eruption proceeds so fast that the chemical affinity cannot become active, the fluid "mother liquor" present must solidify in an amorphous mass, and the volcanic rock has a *vitro-porphyritic* structure. The younger generations of components are then, more or less, completely wanting. Midway between these two structural forms stands the *hypocrystalline porphyritic*, in which the volcanic rock possesses a ground-mass of mingled crystalline separations and amorphous portions of the mother liquor which have congealed. This kind of porphyritic structure is susceptible of a great variety of form, which can be discussed later on.

The comparative microscopical examination of the generality of all crystals of earlier generations (*Einsprenglinge*), on the one hand, and of components of a holo-crystalline ground-mass on the other, teaches that the recurrence of identical, or similar, mineral structures, as they appear among the earlier crystals (*Einsprenglinge*), as well as in the ground-mass, does not in general extend to all of the four groups of components differentiated above. One or more of them are often wanting, and here prevails, in opposition to the law above stated, the rule that almost *never does an earlier group of components appear in the ground-mass when a later group is wanting.* The components of groups 3 and 4 are essentially those which we meet in the ground-masses, only in very basic rocks does the recurrence of the generations go back to No. 2, and very seldom to No. 1. Scarcely any reliable observations have been made as to whether any differences exist between the chemical constitution of components of the 2d group in older and younger generations. On the other hand, by comparative exam-

ination of the feldspar of older and younger generations in the most different porphyritic rocks, it has in part been proven, and in part made very probable, that the acidity of the different generations is in inverse ratio with their age.

From this, as well as from the fact that in general, even in the ground-mass, the succession of the separations is in accordance with the sequence given above, it follows, that not only during the period of intratelluric crystalline development the magma present as "mother-liquor" is more acid than the whole mass of the rock, but also at the moment of eruption, and in every portion of the epoch of outflow, this relation must exist between the remnant of fluid "mother-liquor" then present (considered finally free from water) and the whole rock-mass. On the other hand, at every moment of the development of the rock, the sum of the crystalline separations must be more basic than the whole rock-mass. The latter difference will become smaller and smaller, with the holocrystalline development of the ground-mass, until it is equal to zero. So far as chemical investigations affect the relations here deduced from microscopic observations, they furnish perfect corroboration. It is unnecessary to mention that naturally metasomatic processes (weathering) obscure these relations, and may even obliterate them.

In holocrystalline ground-masses the modality of the structure varies again according as the components show more or less complete idiomorphism, or as this character appears in connection with only a few components, or finally, is lacking in all. The resulting structural relations may, by analogy to the plutonic and dyke rocks, be designated as panidiomorphic-, hypidiomorphic-, or allotriomorphic-granular.

The amorphous or obscurely-defined crystalline parts of hypocrystalline ground-masses in volcanic rocks, are usually called, after the precedent of Zirkel, by the not very happily chosen, but pretty generally accepted name of *base*. Previously, Vogelsang and I had designated these portions, but also unhappily, as *magma*, and this name still appears here and there in literature. It is better to reject it entirely. From grounds which were in part stated on page 6,* and in part are to be sought in the historic development of geology and petrography, the volcanic rocks have been divided into an older and younger class, which are here differentiated as

* S. OF M. QUARTERLY, vol. ix., pp. 366–367.

palæovolcanic and *neovolcanic*. How far this distinction may be vindicated petrographically cannot be discussed here. From the description of both groups given in the following pages, the reader can best form an idea for himself. It is gratuitous to remark that the determination of the age of a considerable number of occurrences, which were referred to the neovolcanic rocks, is not direct and positive, but based upon analogy.

III. A.—Palæovolcanic Rocks.

The members of this division represent in mineralogical and chemical composition a fairly continuous series, which is parallel to that of the Plutonic rocks, except in the above-noted characters. The number of this series is much smaller than that of the neovolcanic rocks. We are accustomed to regard as petrographically characteristic of the older series of eruptive rocks a more lithoidal or stony structure of the ground-mass, while glassy structure is more indicative of the neovolcanic rocks. It is very difficult, and in many cases impossible, to determine whether this difference is primary or secondary when it occurs.

In the palæovolcanic rocks we distinguish, according to the chemical and mineral composition, the following principal groups:

a. Family of *Quartz porphyries*. They are the palæovolcanic equivalents of the *granites*, and in their normal development are characterized by the combination of quartz and alkali feldspars among the older crystals (*Einsprenglinge*).

b. Family of *Quartzless porphyries*. Palæovolcanic equivalents of the *syenites*. They are mineralogically characterized by the predominance of the alkali feldspar and the lack of quartz among the older crystals. The ground-mass often contains quartz.

c. Family of *Porphyrites*. Palæovolcanic equivalents of the *Diorites*. They are distinguished by lime-soda feldspars predominating among the older crystals, and these are accompanied by biotites, amphiboles, or rhombic pyroxenes. There are quartziferous and quartzless varieties.

d. Family of the *Augite porphyries* and *Melaphyres*.

e. Family of the *Picrite porphyrites*. Palæovolcanic equivalents of the *peridotites*. They lack feldspar among the older crystals and in the ground-mass. They are, in general, rich in olivine.

As we see no palæovolcanic equivalents of the elæolite syenites are known up to the present time. Their absence forms a most conspicuous hiatus in this series of rocks.

III. B.—The Neovolcanic Rocks.

This series of rocks is much more extensive than that of the Plutonic or the Palæovolcanic rocks. It should be remembered, however, that for a large number of tertiary and recent eruptives the determination of age is unreliable, and often only reached by reasoning from analogy. The typical form in which the neovolcanic rocks appear is that of streams and sheets; we necessarily often find them as dykes, as so-called volcanic necks, and as plugs, chiefly, however, in very small dimensions. As to how far such intrusive forms may change the normal structure of these, according to the rule for effusive masses, individual description will show.

Like all volcanic rocks, the neovolcanic are often accompanied by light ejected material in a loose or a solidified state.

According to their mineralogical composition, the neovolcanic eruptive rocks may be divided into the following families:

1. Family of the *Liparites* and *Pantellerites*. These are the younger equivalents of the palæovolcanic *quartz porphyries*, and *quartz keratophyres*, and therefore correspond to the *granites* among Plutonic rocks. When normally developed they are characterized by the combination of quartz with an alkali feldspar among the older crystals (*Einsprenglinge*).

2. The family of the *Trachytes* and more basic *Pantellerites*. It forms a parallel with that of the *quartzless porphyries* and *keratophyres* of the older volcanic rocks, and corresponds to that of the *syenites* among the Plutonic rocks. It is mineralogically characterized by the abundant appearance of an alkali feldspar and the absence of quartz among the older crystals.

3. The family of the *Phonolites* and *Leucitophyres*. They are commonly defined by the quartzless combination of an alkali feldspar with nepheline or leucite, or with both of these minerals among the older crystals. No palæovolcanic equivalents of these are known. Among the Plutonic rocks the leucitophyres have no parallel; the elæolite syenites correspond quite exactly to the phonolites.

4 and 5. The family of the *Dacites* and *Andesites*. These are parallel to the diorites among the Plutonic rocks, and to the por-

phyrites among the older volcanic rocks. In mineral composition they are characterized by the predominance among the older crystals of a lime soda feldspar, with which biotite, amphibole and hornblende or pyroxene are associated. There are species with quartz (Dacites), and without quartz (Andesites).

6. The family of *Basalts*. They are the neovolcanic equivalents of the melaphyres, and of certain augite porphyrites (Tholeiite, Labrador-porphyrite). They correspond, therefore, with the gabbros and diabases among Plutonic rocks. There are species with and without olivine. They are characterized mineralogically by the combination of a lime-soda feldspar (usually basic) with augite.

7. The family of the *Tephrites*. These are distinguished by the combination of a lime-soda feldspar (generally basic) with nepheline or leucite, or both of these minerals. No palæovolcanic rocks are known which correspond with them. Among the Plutonic rocks, *theralites* are parallel to the nepheline-bearing division. There are species with olivine and without it.

8. The family of the *Leucite* rocks. This group is also without palæovolcanic or Plutonic equivalents. Olivine may or may not be present. The combination of leucite with augite distinguishes them.

9. The family of the *Nepheline* rocks. They have no equivalent among the Plutonic or palæovolcanic rocks, and are characterized by the combination of nepheline and augite without feldspar. There are species with and without olivine.

10. The family of the *Melilite* rocks. They are, in general, characterized by the combination of melilite and augite. Species free from olivine are unknown. Older equivalents are not yet announced.

11. The family of *Limburgites* and *Augitites*. The former correspond to certain *pikrite porphyrites*, and to the *picrites* up to a certain point. The augitites have no older equivalent. They are mineralogically characterized by the lack of feldspar, nepheline, leucite and melilite.

The families 6–11 are closely allied by marked chemical and structural relationships, and may collectively be designated as the group of the basaltic rocks in distinction from families 1–5, which may be called the trachytic rocks.

A BRIEF REVIEW OF THE LITERATURE ON ORE-DEPOSITS.

BY J. F. KEMP.

THE existence of a literature on ore-deposits was made possible by the development of reasonable and right conceptions in geology, mineralogy and chemistry. It was a fundamental and necessary condition that the principles which underlie the origin and formation of rock masses, whether sedimentary, metamorphic, or eruptive, should be clearly understood, and that by a knowledge of crystal form and exact chemical composition the classification and relations of the different minerals should be brought out before, not alone explanations of origin were to be entertained, but even intelligible descriptions could be written. The rise of this literature marks, therefore, the development of right scientific ideas in the departments named, and its continued development is an illustration and indication of the spread of knowledge and the activity of thought in those lines. It is also true that particular studies of these phenomena have brought to light not a few of the most important of our geological conceptions, and have attained the position of classics in the literature of the science. Nor is less to be expected in the future. Ore-deposits play so important a role in all economic and social organization that they will be developed necessarily in increasing extent, and more and more serve to reveal the subsurface structure of the earth.

Although the works of the early writers are crude, and for our purposes well-nigh useless, they are, nevertheless, of such historical interest as to deserve passing notice. In Saxony, in the mining region about Freiberg, Agricola (1490–1555), often called the "Father of Mineralogy," lived and wrote with much scientific acumen while as yet correct geological methods of investigation were almost unknown. Knowing nothing of crystallography and chemistry, he described and classified the minerals according to hardness, outer form, color and lustre, and naturally his system is very incomplete. A beginning was, however, made. Nicolaus Steno (1631–1686), by birth a Dane, but for many years a student and resident physician in Tuscany, wrote in 1669 a short work,*

* A French translation by De Beaumont is in "Annales des Sci. Nat.," xxv., 1832.

which marks for geological science a great advance. Steno first distinguished the crystalline from the sedimentary, and the azoic from the fossiliferous rocks. He looked below the surface for the cause of mountains and brought to light the movements of the crust, tracing them to volcanic vapors and subterranean erosion. Cracks, slips and faults he cited as proof. But most of all was progress in the study of ore-deposits aided by his views on the growth of minerals, the filling of cavities by solutions and vapors, and by the fundamental idea of metamorphism, which had its rise with him. His work, however, was not as generally known as it deserved, and at the beginning of the eighteenth century, aside from certain advances in palæontology and the significance of fossil remains, made especially by the English, geology became involved in theological conflicts, and was smothered by them. Moreover, what had been done was largely theoretical, and still remained to be worked out step by step by observation. Not until 1762 did Füchsel, a German, publish, with the first of geological maps and sections, his description of certain areas between the Thuringian Forest and the Hartz Mountains.

In 1780, Werner (1750–1817) entered on his professorship in the Freiberg Mining Academy. The drift of his geological doctrines, commonly known as Neptunism, is familiar to every student of the science. These were also applied to ore-deposits, as would be naturally inferred from his surroundings. Although the most famous lecturer and teacher of his time, he has left but one printed treatise, which itself happens to be concerned with this special branch. If now, in accord with Neptunism, we imagine all rocks —schists, gneiss, sedimentary rocks, and even granite and basalt— to be precipitates from the ocean, what more natural than that all contained ore-deposits were formed in a similar way in the containing cavities? Hence the historically interesting, but generally irrational, "Descension Theory" of Werner.

Although giving no such special attention to ore-deposits as Werner, Hutton (1726–1797), and his school of Vulcanists, derived all interbedded deposits, as well as those filling cracks, from igneous sources, and may be considered to be responsible for the "Igneous Injection Theory," which is, in almost all cases, no less inapplicable than the ideas of Werner.

From the close of Steno's career, or say from 1700 to the time of Werner, despite the stagnation of geological advance strictly

so-called, a quite extended series of works bearing on ore-deposits was published by Germans who were engaged in practical mining. These may be found mentioned in v. Cotta,* and from them it appears that almost all the subsequent theories of origin were more or less completely outlined. This, on second thought, is not so surprising, because in the explanations of the origin of limited bodies of minerals there is but little latitude for possible originality, which still keeps within reasonable bounds.

We may now tabulate after v. Herder and v. Cotta, although the same is to be found less completely in Taylor's *Report to the Brit. Assoc.* (1833), and in De la Beche (1839), the ideas on the origin of ore-deposits prevalent at the beginning of this century, giving to each author his date;

1. Contemporaneous Formation (*i.e.*, with the walls), Stahl (1700), Zimmermann (1746), Charpentier (1778), v. Terebra (1785).

2. Lateral Secretion. Delius (1770), Gerhard (1781), Lasius (1789).

3. Descension. Baumer (1779), Werner (1791).

4. Ascension by (*a*) Infiltration, Lasius (1789); (*b*) Sublimation with steam, Lehmann (1753); (*c*) Sublimation as gas, Becher? (1703); (*d*) Igneous Injection, Hutton.

It will thus be seen that almost all the current explanations existed with the exception, which is doubtless as important as any, of the Replacement Theory, especially developed of late by Emmons in the Leadville Monograph, to which reference will be made later on.

In the first forty years of this century the most important additions to the literature appeared in England. The Geological Society of London was founded in 1810 by Wm. Smith. The first volume of the *Proceedings* of the Roy. Geol. Soc. of Cornwall appeared in 1818; that of the British Association in 1833. Various scattered papers appear in these, principally descriptive of the lodes of Cornwall, mention of which is to be found in Taylor's *Report to the British Association* in 1833 on the "State of Knowledge respecting Mineral Veins." Although affording nothing new this paper called attention to the subject, and led to the experiments of Fox† (1836) and Henwood‡ on the electrical conditions of mineral

* Erzlagerstätten, 2d ed., 1859, vol. i., p. 172.

† Published afterwards, "Trans. Roy. Geol. Soc. Cornwall," vol. v., p. 445 (1843).

‡ Jamison's "New Phil. Jour.," Edinburgh, 1837, xxii., pp. 142 and 270.

veins. This idea of the influence of supposed electrical currents traversing veins as a means of precipitating ores from solution was a very attractive one, and received more attention than subsequent experiment seems to have warranted.* Sir Humphry Davy's electrolytic experiments doubtless suggested it.

Sir Henry de la Beche (1796–1855) published in 1839 his classic *Report on the Geology of Cornwall, Devon and Somerset.* Chapters X., XI., and XII. are devoted to the consideration of mineral veins. This work is generally considered the first really notable English publication on the subject, and certainly did serve to spread more widely than any other a knowledge of mineral veins. De la Beche first plots the chief Cornish lodes; shows them to belong to two or three individual systems of faults; discusses the varying richness in different wall-rocks; and gives, as his conclusion, that mineral veins result from the filling of fissures in rocks by chemical deposits from substances in solution in the fissures, such deposits being greatly due to electro-chemical agency. No scheme of classification is given, as the author had evidently only fissure veins in mind.

Later, 1843, Henwood† published a tabulation of the Cornish lodes, giving strike, dip, width, walls, mineral character, etc., which is a monument of careful observation and record.

Meanwhile, before the appearance of De la Beche's work, Fournet, a distinguished Frenchman, had published in France, in the third volume, page 431, of D'Aubisson's *Traité de Geognosie*, a discussion of mineral veins from the French point of view. Abundant material had accumulated for this in the *Journal des Mines* (now the *Annales des Mines*), which was begun under the French Republic in 1794, and continued with this title until 1815. The mineral wealth of France, except in coal and iron, is not, however, diversified or great, but the *Journal* contains much on the deposits of other lands now of historical interest.

At about this stage (1840), a new field was opened to the literature by the establishment in this country of State Geological Surveys.‡ Being supported by popular tax, one of their chief objects

* To be referred to again in connection with the experiments of Barus on the Comstock Lode.

† "Trans. Roy. Geol. Soc. Cornwall," vol. v., pp 1 to 386.

‡ Very complete lists of such governmental publications are to be found in the *Am. Jour. Sci.*, II Series, vol. xliii., pp. 116 and 399, the *Inst. Min. Eng.*, vii., 455,

was always to give a reliable and fair account of the mineral resources of the land in question. These surveys have been repeated in many cases in later years, and more careful descriptions given, but among the early ones, Beck's *Report on the Mineralogy and Economic Geology of New York* (1842) is still a valuable book of reference. Foster and Whitney's *Report on the Lake Superior Copper Deposits* (1850) and *Iron Deposits* (1851), are likewise two valuable works. The former contains a somewhat systematic discussion of ore-bodies (chap. vi.) and foreshadows Whitney's *Metallic Wealth of the United States*. In 1841 the publication of the *Berg und Hüttenm. Zeitung* was begun, and still remains one of the most valuable of the journals relating to mining. Many papers, both descriptive and theoretical, are scattered through its pages.

In 1847 Bischoff (1792–1870) published in Germany the first volume of his *Chemical and Physical Geology*. The author sought to explain geological phenomena by the laws of molecular action. To this end a vast number of analyses were collected, and the phenomena of springs, rivers, and the general circulation of waters, both on and under the surface, were studied, all of which had a more or less close bearing on mineral deposits. The book materially aided advance, especially among the Germans. Within the last few years the same thesis has been taken up by Justus Roth in his *Allgemeine und Chemische Geologie*, and an invaluable compilation and discussion afforded to students.

In 1847 Bernhard von Cotta (1808–1879), professor of geology in the Mining Academy at Freiberg, began the publication of a journal especially devoted to the study of mineral veins, entitled *Gangstudien*, which gradually led up to the author's well-known treatise on ore-deposits. The first volume was completed in 1850, and numbers were published at irregular intervals until 1860, making four volumes in all. The first volume contains a quite complete index compiled by H Müller, of the most important papers and works then published, which bore on this particular department. This and the other volumes also contain detailed descriptions of European and foreign ore-bodies, among which

vii., 466, ix., 621. On the organization of these and later surveys, cf. Powell's Testimony before the Joint Commission, Forty-ninth Congress, 1st Sess., Miscl. Doc., No. 82, p. 1, etc.

Oscar Lieber's work on the itacolumite and gold quartz of the Carolinas, in the third volume, and the first draft of von Cotta's subsequent treatise in the second volume, are perhaps of the greatest interest. Von Weissenbach also gives in the first volume a scheme of classification which, however, has never received any general adoption or notice.*

Mention should be made of Breithaupt's monograph on the *Paragenesis of Minerals* (1849), in which the formation and succession of minerals were very thoroughly treated with especial regard to the origin of mineral veins. Many extremely interesting and instructive instances of pseudomorphs and related phenomena are cited, affording a valuable book of reference, even to this day.

From June, 1853, to and including December, 1854, there was published in New York the *American Mining Magazine*, which, in its three volumes, contains many descriptions of American deposits and much current mining history. In 1854, J. D. Whitney brought out his *Metallic Wealth of the United States*, a book which marks an epoch in the literature, and which was the first general American treatise. A scheme of classification, quite original, is given, and this is followed by a detailed description of the ore-producing localities of this and foreign countries, arranged by metals. For purposes of comparison a brief *resumé* of the scheme is here given:

I. Superficial.		
II. Stratified.	*a.* Constituting the mass of a bed or stratified deposit.	
	b. Disseminated through sedimentary beds.	
	c. Originally deposited from aqueous solution but since metamorphosed.	
III. Unstratified.	*a.* Masses of eruptive origin.	A. Irregular.
	b. Disseminated in eruptive rocks.	
	c. Stockwerk deposits.	
	d. Contact deposits.	
	e. Fahlbands.	
	f. Segregated veins.	B. Regular.
	g. Gash veins.	
	h. True or fissure veins.	

Many features of this scheme run through subsequent writers. The third division, under stratified, is open to criticism, because in

* Cf. Metallic Wealth of the U. S., p. 44.

its chief example, magnetite lenses, deposition from solution is not demonstrated. Several other types have also been introduced in the unstratified. It may be added that the *Iowa State Report of* 1858 contains, in the chapters relating to economic geology, some general remarks by Prof. Whitney, together with descriptions of the local iron and lead deposits.

Von Cotta published, in 1859, the second edition of his *Erzlagerstätten* or *Treatise on Ore-Deposits*, which, in Prime's translation, came out in English in this country in 1870. This work is, perhaps, the most important one yet published, and still is regarded in this country as the chief authority. The work is in two parts; the first is a general treatise, containing descriptions of the minerals useful as ores and occurring as gangue; of the associations of the same; of the geological features of ore-bodies, their origin, etc., and many generalizations on the experience which had been gained in mining operations. The scheme of classification as given in the earlier edition in the *Gangstudien* is somewhat modified, and in Prime's translation further changes are made in the line of simplification. In the last-named work we may infer it stands as finally approved by the author, and is:

- Regular Deposits.
  - Beds.
  - Veins.
    1. True (Fissure) Veins.
    2. Bedded "
    3. Contact "
    4. Lenticular "
- Irregular Deposits.
  - Segregations
    - Recumbent, also
      1. Floors.
      2. Contact Masses.
      3. Cavity Fillings.
    - Vertical,
  - Impregnations (Disseminations).

This classification is simple and serviceable, but, as further discussion will show, two terms in common use in America and very useful (gash veins and segregated veins), which appear in Whitney's scheme and later American ones, are omitted, and the chamber or cavity fillings deserve greater prominence, while undue importance is given to mere outward form.

(To be continued.)

HIGH BRIDGE—NEW YORK.

BY C. D. STARR.

THE most difficult problem which presented itself to the engineers employed on the construction of the Croton Aqueduct, fifty years ago, was the crossing of the Harlem River. The river at the point chosen was 600 feet wide (now somewhat narrower), 16 feet deep, and lies nearly north and south between high and steep bluffs. Both slopes are of gneiss rock, more or less covered by earth and vegetation, and the bed of the river is mud, sand, boulders, and soft rock to a depth near the middle of 100 feet. The eastern or mainland side of the valley is about 150 feet above the river, and descends at an angle of 20 degrees to a stretch of level ground which was 300 feet wide to the river. The western or Manhattan shore is over 200 feet high, and slopes at 35 degrees to the edge of the river. The aqueduct follows the course of the river on each side, and turns at right angles to meet the bridge, which points nearly east and west. The latter is of masonry throughout, 1420 feet long, 28 feet wide on top, and 125 feet high. It has 15 arches, all semicircular, eight of which have a span of 80 feet and traverse the river and adjoining railroad, and the remaining seven are of 50 feet span. These arches are supported by piers of different thicknesses, according to their location. The three largest are 20 feet thick at the spring-line of the arch, and are situated at each end and in the middle of the range of large arches. The piers between these are 14 feet thick at the spring-line, and those outside, supporting the smaller arches, are 7 feet. The height of the piers above high-water, is 60 feet to the spring of the large arches, and 75 feet to the spring of the small arches, giving an opening of 100 feet between high-water and the soffit. Abutments at either end terminate the bridge, and connect with solid walls of dry masonry, with cement faces, which form the approaches. The bridge supports a gallery, in which are the pipes that carry the water, and which terminate at each end of the bridge at a gate-house connecting with the masonry conduit which forms the rest of the aqueduct. The gate-house at the east end is provided with waste-gates, by opening which the flow of water may be turned into a brick sewer discharging into the river.

Both the abutments, and piers Nos. 1, 2, 13, and 14, counting from the east end, are on gneiss rock. Piers No. 7, 8, and 9, are on marble, and the remainder on piles. Where the piers came on rock, it was levelled off in one plane, or in steps, according to its inclination. The foundation of the river piers was accomplished as follows: The mud having been removed by a dredging-machine, a coffer-dam was settled on the sand, and sheet-piling driven outside of it to the rock, where it was accessible, and otherwise to a stratum impervious to water. Earth-filling was then placed around it, the water pumped out and the excavation begun. The work of piling was accomplished entirely to the satisfaction of the engineers, and its excellence has been proved by the perfect stability of the bridge. The piles were of oak, 11 inches at the small end, and were, in nearly every case, driven 2 feet 6 inches between centres. The resistance attained for each pile was 1 inch under 1200 pounds, falling 30 feet. They were capped with a 12 × 12-inch white-oak timber over each row of piles. Across these was another set of timbers, following the rows the other way, with timbers also between them leaving 3-inch spaces. The piles for the land piers were cut off below high-water mark. For pier 8 the excavation was made to 17 feet below high water; for pier 9, to 35 feet below high water; for pier 10, to 30 feet below high water, and then piles driven 3 feet apart for 30 to 35 feet more.

The scaffolds and centres used in the construction of the shafts and arches were built up on the piling of the coffer-dams. The masonry throughout the bridge is of granite, dressed to make joints of $\frac{1}{8}$-inch, with a batter on all sides of $\frac{1}{4}$-inch to the foot. The piers are built with interior spaces, for the following reasons, presented by Mr. John B. Jarvis, the chief engineer: A greater width of pier can thus be obtained for the same cost, which is better able to resist the horizontal thrust of the arches. In ordinary cases, particularly for arches of small span, it is the usual practice to give the proper breadth of pier by filling the interior with rubble masonry, dressing only the face stone. But in piers of great height, designed for arches of large span, this method is unadvisable, because the rubble is liable to settle more, and eventually force the face stone to bulge outward, and injure, if it do not destroy the work. A second reason is the tendency which a large mass of masonry has to prevent the uniform and rapid hardening of the cement. The spandrels of the arches were carried up solid for some

height, and then built with spaces to 6 inches above the arch stones. The spaces were then covered with slabs and a level floor made for the pipe gallery. This gallery is 13½ feet wide, 15 feet high, 1370 feet long, and is drained by openings into the hollow spaces of the spandrels, which in turn drain into the piers, and these to the exterior near the base. It is lighted and ventilated from the roof, and approached by doors cut in the masonry at the sides near the east end of the bridge, which are large enough to admit the introduction of cast-iron pipe, or wrought-iron plate, or any other material for repairs. The roof is a flat brick arch, abutting against cast-iron skew-backs kept in place by wrought-iron tie-rods. The arch is made water-tight by a covering of concrete and asphaltum. In the gallery there are three pipes. Two are of cast-iron, 36-inch diameter, supported on concrete piers a little above the floor, and 12 feet below the level of the aqueduct. Between these, and raised on standards so as to occupy the centre of the gallery, is a third pipe, 7 feet 6⅝ inches diameter on the inside, constructed of wrought-iron plates. These plates are 8 feet by 6 feet by ½-inch, butted together and the joints made by horizontal and transverse straps on the outside, each strap being 9 inches wide and ½-inch thick. There are four rows of ¾-inch rivets in each strap. In the interior the rivets are countersunk to the plane of the pipe, thus affording a smooth surface and avoiding unnecessary friction. Both the exterior and interior surfaces are well painted to preserve them from rust. The cast-iron stanchions or pedestals supporting the pipe are 12 feet apart, and are of sufficient height to allow 3 feet of clear space between the large pipe and the small ones, to admit of the free movement of workmen in repairs and cleaning. Their tops are 2 feet 6 inches square, and are planed to a smooth and accurate surface to permit the proper action of the rollers and saddles by which they are surmounted. At the centre of the bridge, the saddle rests on the pedestal without the intervention of the rollers. For the rest of its length in each direction there are three cast-iron rollers on each stanchion, which are kept in their proper relative positions by an iron frame. Upon these rollers rest the saddles which come into immediate contact with and support the pipe itself. The base of each saddle is of the same size as the top of the pedestal, and is in a similar manner planed to a smooth and uniform surface. At each end of the pipe, and built into the masonry connecting the pipe with the gate-house, there is a cast-iron cylin-

der into which a cast-iron ring, which forms the end of the pipe, is inserted and fitted with great accuracy, and the surfaces of contact faced with brass. Thus there is a sliding joint at each end of the pipe which, together with the rollers between the planed surfaces of the pedestals and saddles, fully provides for the longitudinal contraction and expansion of the pipe under any variations of temperature it may be subjected to.

The contract for the construction of the bridge was signed August 13th, 1839, and the work was to be completed in four years. The lowest bid was $738,000 and the next $755,000. The aqueduct was opened July 4th, 1842, but the construction of the bridge went on slowly till 1848. Water was admitted to the first pipe in May, 1848; to the second in July of the same year; and at the end of October, the filling and curbing being completed, the contractors were discharged. The total cost of the bridge was $963,427.80. In order that the city might have the benefit of the supply during the interval between the completion of the aqueduct and bridge, a temporary 36-inch pipe was laid across the river on the filling enclosing the coffer-dams, which, by degrees, had formed an unbroken embankment. At the lowest point of this temporary pipe a 12-inch pipe ran out horizontally 80 feet and was turned up at the end with a 7-inch orifice. Through this the water was allowed to play in a fountain which is said to have risen 115 feet with 2 feet of water in the aqueduct.

The bridge was originally finished off at the top with a different arrangement from that now existing. Only the two 36-inch pipes were laid, and these were covered to a depth of 5 feet with earth confined by parapet walls to the same height. To increase the capacity of these pipes for conveying water, an extra fall of 2 feet was given across the bridge, and the aqueduct on the southern side of the river is constructed 2 feet lower than the regular grade to agree with this arrangement. Three years after the completion of the bridge it was said that a grave error had been committed here. The aqueduct was built for 60,000,000 gallons per day, and the two lines of pipe would carry but half of that. Moreover, to make the siphons do that work a head of 2 feet had been lost after maintaining it at great cost by bridges and embankments through a distance of thirty-three miles. It was claimed that the piers were abundantly strong to have built the bridge up 14 feet to the level of the aqueduct and to have carried the latter right across

with the addition of an iron lining, as in the case of the bridges across the Sing Sing Kill and Glendinning Valley, arriving on Manhattan Island with a head of 117 feet instead of 115.

In reply to this it was stated that the increase of cost would have been $75,000, which was considered too much for the advantage gained; and, furthermore, in the case of a conduit with iron lining, there would be more or less leakage due to the change of shape in the lining produced by variations of temperature, and this would injure the masonry and eventually destroy it. At the end of ten years an increased supply became necessary, and was secured by the addition of the large pipe previously described. At the same time the earth covering was removed, the side walls were raised, and a roof put on, making the gallery complete, in 1862. To keep up the supply of water to the city during the progress of the work of connecting the new pipe, it was necessary to change the entrance-gates of the old pipes from the front to the side of each gate-chamber, and to do this also without drawing off the water from the aqueduct and gate-chambers. A caisson or coffer-dam of wood was framed and sunk to its position against the inner face of the north wall of each chamber, leaving a narrow space between the masonry and the inner face of the coffer-dam. The water from this space was then pumped out and the walls cut away with drills for a space of 12 feet in length and 15 feet in height; the depth below the surface of the water at the east gate-house being 9½ feet, and below the floor of the gate-house 1½ feet. At the west gate-house the depth below the floor was 4 feet. The masonry was then rebuilt with the proper variations for new gates and the reception of the mouth-pieces for the two 36-inch pipes. From these points two new lines of pipe were carried round on the outside of the gate-houses and down to the floor of the bridge to the point at which the removal of the old pipes was necessary. Here the pipes were, one at a time, cut off and connected with the new lines leading into the sides of the gate-houses. The water was then passed through the old pipes by these new connections and the fronts of the gate-houses were free for further operations. The masonry of almost the entire fronts below the water-line was removed in the same manner as it had been from the sides, and the new construction went on without interruption. During the whole of this work there was at no time a stoppage of the entire flow of water into the city. It was not shut off at all for any of the opera-

tions at the gate-chambers themselves. When the old pipes were disconnected from their original entrances to be diverted to their new course, the water from each one in succession (that is, one-half the daily supply) was shut off, but the time for which it was thus stopped was so short that the difference was not felt in any part of the city.

Before the construction of the bridge was finally decided on, a plan was adopted to carry the water across the valley in iron pipes, which would be under ground to the water's edge, and then on a low stone embankment 4 feet above the surface of the water until, near the middle of the river, it would rise on a straight grade to the western shore. This would give opportunity for a circular arch of 40 feet radius on abutments 10 feet above high water, and would allow the passage of vessels of 200 tons burden. Beyond this arch followed three smaller ones on the slope of the hill and a solid wall finished the distance to the aqueduct. Suitable parapet walls were to be built along the sides of the embankment to sustain a covering of earth. Four 36-inch pipes were calculated to give the required flow. This work was put under contract and already begun when the efforts of adjoining property owners secured the passage of a law requiring an opening to 100 feet above high water, or the construction of a tunnel in place of the bridge. Plans for a tunnel were accordingly prepared, which were as follows: Four 36-inch pipes 4 feet below the surface of the ground led to the river and passed under it through two adjoining tunnels each 12 feet high and 8 feet wide, the top of their masonry being 18 feet below high water. The estimated cost was $640,000, which was $200,000 less than a bridge, but the uncertainty of this estimate and the discouraging history of the Thames tunnel turned the scales in favor of the bridge.

GEOLOGICAL NOTES.

BY PROF. J. S. NEWBERRY.

II.

THE ORIGIN OF THE LOESS.

THE loess is an arenaceous calcareous clay, yellowish brown in color, found chiefly in the valleys of certain rivers such as the

Rhine, the Danube and the Missouri. The loess belongs to the category of superficial deposits, being covered only by alluvium and where in contact with the till or boulder clay—the ground moraine, formed by glaciers—it is found to rest upon that, and is thus proved to be of more recent date. Usually the loess shows little signs of stratification; sometimes it is obscurely bedded, but often forms cliffs or walls thirty, fifty or even one hundred feet in height where the material is very nearly homogeneous throughout. Unlike clay, loam or sand the loess is remarkably resistent to weathering, and exposed cliffs of it seem to be as little affected by rain or frost as many varieties of solid rock; and where faces of loess have been marked with inscriptions these have remained legible for a surprisingly long time, when the softness of the material is considered. Another peculiarity of the loess is that it contains many calcareous concretions, usually columnar or cylindrical, though irregular in diameter, direction and surface. It also contains traces of what are apparently the roots of plants deeply penetrating the mass and the concretions referred to above have been often formed around such roots.

The loess of the Missouri Valley is sometimes called the *bluff formation* because, from its power of resisting erosion, it forms vertical faces or "bluffs." These are, however, often only the facing of the rocky cliffs which constitute the walls of the valley, formed long ago, and filled in comparatively modern time with the loess, now but partially removed.

The fossils of the loess are usually few in number and are chiefly land shells and the bones of land animals, but occasionally fresh water mollusks are found in considerable abundance.

The origin of the loess has recently become a subject of earnest discussion among geologists. It was formerly supposed by all to be a river silt, and that is the view advocated by Lyell in his description of the loess of the Rhine, but Baron Richthofen, in the study of the great area occupied by the loess in China, was led to consider the whole formation as an accumulation of wind-borne dust. This view is quite generally though not universally accepted by the geologists of the old world, but there are serious difficulties in its application to the loess deposits of Europe and America. These are,

1. The limitation of the loess of Europe to the Valleys of the Rhine and Danube. It is difficult to understand how an æolian

deposit should be so restricted, while a fluviatile or lacustrine sediment would necessarily be so. The loess of North America is not restricted to so narrow limits, and yet it is mostly confined to the Valley of the Missouri and the adjacent country which would be flooded by its waters if their flow was impeded.

2. *No such deposit as the loess is now known to be accumulating through the agency of wind.* Nothing of the kind has been observed by the writer in repeated journeys through the arid and windy regions of the interior of our continent where the conditions would seem to be specially favorable and where dust storms are common; the material transported by the wind being all washed away by the rain and snow.

The absence of stratification in the loess is a feature difficult to reconcile with aqueous deposition, as it would be evidence of a constancy in conditions of sedimentation which is certainly unusual though not impossible.

Waiting further light on this interesting question, the writer still adheres to the theory of aqueous deposition for the origin of the European and American loess, because it is more like an accumulation of river silt than any other deposits now forming. The yellow waters of the Missouri are now always loaded with sediment which in chemical and physical characters is scarcely different from the loess, and, if the current of the Missouri were checked by a dam or by the influx of the waters of the gulf, it would precipitate a sediment undistinguishable from the loess, unless laminated by variations in the volume of the flow. If the sediment carried by the Missouri were distributed through a considerable body of still water into which it flowed, the sediment would be deposited with a good degree of constancy. We can imagine circumstances in which the amount of sediment transported would be subject to very little variation, and hence the deposit formed at the bottom of the receiving basin would be homogeneous. The rivers which are fed only by rain vary greatly in their volume and the amount of sediment they carry, but the rivers which drain glaciers are much less variable in their flow and the silt they carry is always abundant.

The region drained by the upper Missouri was once occupied by glaciers more extensive than those of Switzerland, and it is certain that its current once carried a larger and more constant burden of silt than now. We have also evidence that the gulf waters at one time reached up to the present mouths of the Missouri. Putting

these facts together we have the materials for a theory of the formation of the loess which is not difficult to understand or believe. Similar causes would produce like results in the valleys of the Rhine and Danube, and we have only to imagine, what we know to have been true at one time, that these streams drained a great glaciated area in Central Europe, and their ice cold and lifeless waters transported a large and constant quantity of sediment and precipitated this near their obstructed mouths, and we have supplied an explanation of the phenomena which is not only possible and probable, but we may almost say inevitable.

Marble Deposits of the Western United States.

The marbles of the Eastern United States and Canada are briefly described in my report on the building stones shown at the Centennial Exhibition, at Philadelphia, 1876. (Report of Group I, p. 137.) Of these the most important deposits of white marble and the only ones extensively worked are in Rutland Co., Vermont. White marbles of coarser texture and valuable as building stones occur and are quarried in Massachusetts, Connecticut and Eastern New York. Similar deposits to these are also known to exist in Pennsylvania, Maryland, Virginia, North Carolina and Georgia, but they are not yet very much used.

The colored marbles quarried in the Eastern States all come from the shores of Lake Champlain. Under the general name of Winooski marble, a considerable quantity is sent to market from this region, and some of the many varieties found there are held in deservedly high esteem. As mentioned in my report, still more beautiful colored marbles occur in Maryland, and we may expect that at no distant day some varieties will be produced there which will rival in beauty and excellence any of the marbles imported from the old world. The colored marbles of Tennessee, both the Knoxville and Dougherty varieties, have come into extensive use in many parts of the country and are highly popular. At Hudson and Lockport, New York, fossiliferous limestones are quarried which are sold as marbles and are used for the same purposes, but strictly speaking they are not such. So the "Athens marble" of Illinois, so much used as a building stone in Chicago, and the "black marble" of Glenn's Falls, N. Y., and Williamsport, Penn., are unmetamorphosed limestones and therefore not, strictly speaking, marbles.

Since marbles are confined to mountain ranges or districts underlain by metamorphic rocks, in the broad area of the Mississippi Valley no marbles have been met with. When we have crossed the plains and have reached the Rocky Mountains we find in numerous localities outcrops of limestones which have been changed in color and rendered crystalline by the hydrothermal action which has metamorphosed all the associated rocks. So in the Wasatch of Utah, the Lost Mountains of the Great Basin, and the Sierra Nevada of California, I have found marbles, colored or white, good or bad in many localities. Most of these have, however, up to the present time not been worked and they have attracted little attention; for until the means of transportation shall be greatly improved it is evident that no marble bed in the western mountains, however beautiful or excellent, can be utilized. Railroads are, however, being rapidly pushed across our Western States and Territories on many lines, and it is probable that as they approach some of the marble deposits referred to they will give them a value or make them the basis of speculation, so that it is desirable the truth should be known about them.

Marbles of Tempiute Mountain.

In the southeastern part of Nevada, near the west line of Lincoln Co., stands a detached mountain which bears the above name. It rises to the height of about 2500 feet above the level plains which border it on either side. It is composed of a block of sedimentary rocks which have been heaved up to an angle of 45°; the eastern slope being formed by the upper surface of the highest stratum, the western face the plane of a fracture and fault. The rocks are Palæozoic, the lowest member being a quartzite apparently the equivalent of the Potsdam sandstone; the middle and upper portions of the series are limestones, massive or shaly. Immediately above the quartzite the limestones are metamorphosed and converted into marble; higher up they are less changed and contain some Lower Silurian fossils. The marble varies in color from pink to black and is variegated in several ways. Some has been shattered and the cracks filled with calcite. Where the ground is black, and the veins pure white, we have a marble much like the so-called Egyptian—really Genoese—formerly so popular, and quite as handsome. Other layers are limestone-conglomerate or breccia made up of pebbles, rounded or angular, of many colors, principally

gray, white or black, in a dove-colored paste. Again some beds are variously banded with gray, black, brown, red, pink, etc. All these varieties take a very high polish and are scarcely inferior in beauty to any marbles imported from the old world.

At the present time Tempiute Mountain is 150 miles distant from the nearest railroad, at Eureka, but one or more railroad lines will soon be constructed through Southern Nevada, and they will perhaps come so near to Tempiute Mountain as to afford an outlet for its peculiar and beautiful marbles.

White Marbles of Utah.

On the west side of San Francisco Mountain in southwestern Utah there are heavy beds of white marble which appear to be of good quality. They are about three miles in a direct line from the town of Frisco, the end of a branch of the Utah Southern R. R., but could only be reached by a longer and circuitous route. Some quarrying must be done there before it can be shown that any of this marble is so pure in composition and color as to be worth taking to market.

In the Wasatch Mountains, east of Salt Lake City, white marble occurs which has been to some extent quarried, but none of the specimens I have seen are of really fine quality. It will furnish handsome monuments, but is hardly fit for statuary.

White Marbles of Western Colorado.

On Yule Creek, a branch of Crystal River, 50 miles south of Glenwood Springs, in a series of massive gray Palæozoic limestones, which there form hills and mountains, is a belt of white marble apparently superior in quality to anything found elsewhere in the United States. The marble belt is about 100 feet in thickness and may be traced for five or six miles. Nearly all the marble is either pure white or white slightly clouded with gray or blue. On the east side of the belt are also some layers of very beautiful blue or dove-colored marble. So far as one can judge from exposures much of this deposit deserves to be classed as statuary marble, and some of it is apparently equal in quality to that taken from the quarries at Carrara, Italy, or the Grecian Parian or Pentellic marbles. Some of the layers are rather coarse-grained like loaf sugar, others are exceedingly fine and compact. A boring has been made by a diamond drill to a depth of 75 feet across the white layers, and the

core taken out, which I saw, fully confirms the favorable impression made by the outcrop and seems to prove that the marble is sound and strong, as well as pure and handsome. A railroad will probably soon be constructed to coal mines not far distant from this marble belt, and it is quite possible that it will be found of such a quality as to justify its transportation to Denver and even to the cities of the Mississippi Valley.

CONDITIONS AFFECTING THE FLOW OF STREAMS AT THE UPPER WATERS OF THE MISSISSIPPI AND VICINITY.*

THE primary requisite for a stream of water is the rainfall; but while this is so evident, it is hardly correct to say that the discharge from a given area depends on the rainfall upon that region. The flow of the streams which drain the surface of the land depends so much upon the topography, the character of the soil and underlying rock, the temperature and winds, and the storage capacity, that it is impossible to determine any definite ratio of general application between the discharge of streams and the annual precipitation. The most that can be done is by experiment, observation, and calculation to find, as nearly as possible, the effects which the different circumstances met with in nature have upon the waters of the earth in making their circuit between the clouds and the sea.

It is the object here to consider the conditions affecting the flow of the rivers in the region about the sources of the Mississippi.

First. The annual precipitation is not so great upon these inland states as upon those bordering the ocean. The heaviest precipitation upon the area under discussion averages about 35 inches, while the lightest does not exceed 15 inches per annum. This is, of course, to the detriment of the water-powers; but it is offset to a large degree by other considerations, as will presently be noticed. The diminution in the precipitation is general from

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* Taken from the Report on Water-Powers for the Tenth United States Census, recently published.

east to west, with local variations, perhaps owing to the proximity of the great lakes. In the upper peninsula of Michigan and northeastern Wisconsin the annual precipitation averages at least 35 inches; around Lake Superior, 30 to 35 inches; and upon the upper waters of the Mississippi and the sources of the Red River of the North, 25 inches; which is the amount used by the United States engineers in making calculations for the reservoir system on the upper Mississippi. From the sources of the Red River of the North westward the amount of annual precipitation rapidly falls down to 15 inches, or even less in Dakota. Most of the rain and snow of this region appears to be due to the condensation of the moisture in the warm currents of air which sweep up the valley of the Mississippi from the Gulf, and the sudden decrease of moisture at the eastern portion of Dakota marks the margin of the main effects of these vapor-bearing Gulf currents.

The high northern latitude causes cold winters, but the summer temperature is much influenced by the warm air from the Gulf of Mexico. In the far Northwest the climate is very much modified by the softening influence of the Japan current in the Pacific ocean, whose effects are felt even in Dakota, tempering the winter climate to a great extent.

The temperatures given below are averaged from the report of the Smithsonian Institution. More detailed tables are furnished on succeeding pages. For the basin of the Red River of the North in the United States the summer temperature averages 65 to 70 degrees, and the winter temperature 8 to 10 degrees Fahrenheit above zero. The temperature about the sources of the Mississippi is about the same. On the westward drainage area of Lake Michigan the average summer temperature is 68 to 70 degrees, and the average winter temperature about 20 degrees Fahrenheit above zero. This large difference of 50 to 60 degrees between the average temperatures for the two extreme seasons of the year, together with the fact that the winter winds are more generally dry winds from the northward than those of summer, must exert considerable influence upon the distribution of the precipitation throughout the year.

Turning again to the report of the Smithsonion Institution, and selecting characteristic data, we find these results:

Distribution of Annual Precipitation, in Inches.

Region.	Locality.	Spring.	Summer.	Autumn.	Winter.	Total.
Basin of the Red River of the North	Fort Ransom, Dakota.	5.14	4.96	3.38	1.82	15.30
	Breckinridge, Minnesota.	5.14	12.05	3.17	2.45	23.08
Western drainage area of Lake Michigan	Appleton, Wisconsin.	7.65	10.24	6.92	3.70	28.51
	Embarrass, Wisconsin.	8.14	12.49	8.21	5.73	34.57

Of all four seasons the summer has the heaviest precipitation and the winter the lightest, almost exclusively consisting of snow. On this depends an important feature of the streams, the June freshets. But the effect of the cold winter temperature is not confined to the distribution of the precipitation. After it has reached the earth the icy grasp of winter, to a large extent, holds the moisture fast until the warmer air of April and May releases it, and then there is a spring freshet, caused by the melting snow and ice.

The fall rains, which are relied upon to fill the springs for the winter's flow, often produce high water in the streams. In normal years the low water takes place in late summer and early autumn, before the rains of fall have replenished the streams, and in winter, when the sources of supply are to so large an extent frozen solid. It is evident that the cold winter must have an injurious effect upon the steadiness of flow, which is not experienced to nearly so great an extent by the southern rivers. Those streams have in this respect the advantage of the northern water-courses, but it will be shown how the injurious influence of the cold winters is remarkably counteracted.

In a rocky mountainous country, where the only level land is the narrow flat at the bottom of the valley, the rain, as soon as it falls, rushes immediately down the mountain side and is wasted in sudden floods—a state of affairs most inimical to the interests of water-power; and it is largely from this cause that in the New England States the creating of artificial reservoirs becomes such an

important item in the improvement of them. In the Northwest the case is, to a certain extent, just the opposite. The tendency is for the rain to soak into the ground and gradually find its way to the water-courses; and hence, what would be in the one place a disastrous flood, is here distributed through several days, or even weeks, and gradually disappears.

The only streams we have dealt with that in this respect at all resemble the typical mountain stream are some of those discharging into Lake Superior; but even with these the effect of rocky, steep drainage is much mitigated by level lands upon their upper waters. There are also some streams in the comparatively level prairie which are very unsteady, but these are hardly more than drains for the surface-water, and, not being fed by springs or lakes to any extent, cannot be taken for comparison.

The drift, as has been described, is very irregular in character, and where the clay is replaced by sand and gravel the absorption of the moisture is very great. This seriously diminishes the flow of the streams in the immediate locality, but, nevertheless, is often of great value in maintaining the flow at some other place, for the water issues in copious springs at a lower point. Thus, on the south shore of Lake Superior there is an extensive sandy ridge upon which there are no streams, but at its base there are a large number of beautiful springs of clear running water, which feed the Bois Brulé and neighboring rivers, often bubbling up from the sandy bed of lakes. In northern Minnesota, also, there are sand ridges exerting their influence upon the rivers there. In scarcely any place can this effect of sand ridges be more marked than in the State of Mississippi, where the sand-hill streams often have a mill within a few rods of their source and are an unfailing source of moderate power throughout the year.

In some localities it is difficult to see how this absorptive power of sand and gravel beds can have any effect but positive injury upon the water-powers, as the water-bearing layers strike too low to feed the rivers in the water-power regions.

For example, the valley of the Red River of the North is underlaid by water-bearing beds, which receive their supply from where they outcrop on each side of the river and within its basin. The result is that water which would otherwise flow into the tributaries of the main river is carried down beneath the river bed, and, if returned at all to the stream, it is far below the region in which its

water-powers are situated. Several fine artesian wells in the valley are fed by this storage.

The old Archaic rock which underlies the soil over so large a portion of the northwest is hard and solid and impervious to water; but the newer formations are not so resistant, and to them some loss is doubtless due. Thus, there are many artesian wells in eastern Wisconsin which get their supply from the rocks, which there have a southeastern dip. Water percolates from the outcrop down through fissures, and probably a considerable amount thus finds its way to Lake Michigan underground, without ever entering the legitimate surface-channels. At many places along the Mississippi Valley are artesian wells, fed by the water drained in this manner from the surface streams. What effect this has in reducing the flow of the streams it is impossible to determine, but that it exerts some influence is self-evident.

The woodland which yet covers so large a portion of Wisconsin, Minnesota, and Michigan, cannot but be of value in steadying the flow of the streams. The grasses, roots, and decaying vegetation of a forest retard the escape of water, while the shade also prevents excessive evaporation. It must not be overlooked that trees, in growing, take up and dissipate an enormous amount of moisture, which is returned as rain, but is kept from reaching the streams. This very action, however, in making the distribution of the precipitation more uniform, would have a tendency to equalize the flow of the streams, and the universal testimony throughout cleared countries which were once well-wooded is to that effect. Sir Gustav Wex, in a treatise on the subject, bears testimony to this result from the cutting of the European forests, the older of our states testify to it; and even in Ohio, which has been settled almost within a half century, the complaint is almost universal among the millers about the change for the worse in the steadiness of many of the streams. There the cause is largely the draining and plowing of the land, whereby the water reaches the creeks in a much shorter time than when the land is marshy and overgrown with thickets.

In some prairie regions, however, the effect of cultivating the land has been very different; drains have made marshes and areas of land tributary to the streams where evaporation formerly took all the water which did not sink into the soil, and some streams have been very materially increased in their volume by this means, as well as improved in their uniformity of flow.

In Kansas the curious result of farming has been to increase the rainfall. The theory is that the breaking of the tough prairie sod makes the soil more pervious to moisture, and hence immediate surface discharge is decreased, absorption and evaporation are increased, and consequently the rainfall is augmented.

It has been said that the injurious effects of the cold climate upon the streams in diminishing their discharge are remarkably counteracted, and surely a glance at the map will satisfy all familiar with the effects of lakes of the truth of this statement, for if natural reservoirs are of any value in regulating the flow of streams, certainly the rivers of the northwest must be extremely steady. A very large portion of Wisconsin and of Minnesota, but especially of the latter state, is almost literally covered with lakes, varying in size from the smallest pond to bodies of several hundred square miles in extent. The map of the lake region of the Red River of the North will serve to illustrate this. A count from large and detailed State maps of Minnesota and Wisconsin, and from the land-office maps of Dakota and the upper peninsula of Michigan, gave these results:

Distribution of Lakes, According to State Boundaries.

	Number.
Minnesota,	4,920
Wisconsin,	2,465
Upper Peninsula of Michigan,	523
Eastern Dakota,	133
The entire region under discussion,	8,041

Distribution, According to Drainage Basins.

Upper Mississippi River.

Minnesota,	3,817
Wisconsin,	1,859
Dakota,	46
North of the Northern Pacific Railroad,	954
West side of river and south of Northern Pacific Railroad,	2,023
East side of river and south of Northern Pacific Railroad, in Minnesota,	420
Total in Minnesota, Wisconsin and Dakota,	5,256

Red River of the North.

Minnesota,	700
Dakota,	87
Total in Minnesota and Dakota,	787

Rainy Lake Region and Northern Shore of Lake Superior.

Minnesota,	365

Southern Shore of Lake Superior.

Wisconsin and Minnesota,	186
Michigan,	164
Total in Minnesota, Wisconsin and Michigan,	350

Western Shore of Lake Michigan.

Wisconsin,	438
Michigan,	359
Total in Wisconsin and Michigan,	797

Data Concerning the Larger Lakes.

Drainage Basin.	Lake.	Locality.	Area.	Drainage Area.*
			Sq. Miles.	Sq. Miles.
Upper Mississippi	Mille Lacs.	Minnesota.	186	226
	Leech Lake	Minnesota.	176	1,238
	Lake Winnibagoshish	Minnesota.	68	1,350
	Cass Lake.	Minnesota.	34	1,008
Western shore of Lake Michigan.	Lake Winnebago.	Wisconsin.	199	6,046
Red River of the North	Red Lake.	Minnesota.	250	2,149
	Otter Tail Lake	Minnesota.	20	1,442
Rainy Lake Region and northern shore of Lake Superior	Lake of the Woods	Minnesota and the British possess'ns.	†954	.....
	Rainy Lake.	Minnesota and the British possess'ns.	234	.....
	Vermillion Lake.	Minnesota.	59	536

The maps show that by far the greater number of these lakes are about the headwaters of the rivers, and hence their effect in regulating the flow is much more general than if they were distributed farther down stream. If it were not for the immense number of natural reservoirs these streams would be very unsteady.

We are not without cases whereby we may judge of what the conditions of the water-powers would be did not these lakes dot the surface of the land. In Dakota there are comparatively few lakes, and the streams are very unsteady, the headwaters of many of them literally freezing solid in winter. It is true that the pre-

* Including water surface.

† This is less than the true amount, as the extreme northern extension of the lake was not represented upon the map from which the measurement was taken.

cipitation is much less there; but, allowing for the difference in rainfall, a simple calculation shows that the ordinary low-water discharge is only about 20 per cent. of what it would be were the topographical conditions similar to those in the lake region to the eastward in Minnesota. This calculation is made on the assumption, that the evaporation bears a constant ratio to the amount of precipitation, which is not strictly correct; but the result serves to give an idea of the effects produced by the lakes. As was just mentioned, the discharge per square mile of the lakeless regions is sometimes reduced absolutely to zero at the headwaters of the streams.

The influence which the lakes exert cannot be better illustrated than by the estimates of the ordinary low-water discharge per second per square mile of drainage area, for different places along the Red River of the North, as given in the table at the close of the section devoted to that river.

The remarks preceding the tables explain their peculiarities. The tables are derived from a comparison of the upper Mississippi above St. Paul, and of the Red River of the North at the crossing of the national boundary-line. It must be borne in mind that the sources of the Mississippi abound in lakes, while, except at the extreme headwaters, the Red River of the North has comparatively few lakes. The very light rainfall over a large portion of the basin of the latter stream would also account for much of the difference in the nature of the two rivers.

River.	Area Drained.	Estimated Ordinary Low water Flow per second.
	Square Miles.	Cubic Feet.
Red River of the North at the national boundary	39,577	2,800
Mississippi River at St. Paul	36,741	About 7,000

The ordinary low-water discharge of the Mississippi at St. Paul is more than twice that of the Red River of the North at the national boundary, while the area tributary to it is 3000 square miles less. The following estimates of the ordinary low-water discharge, for several of the streams of the Northwest, were obtained mostly by comparing actual gaugings with the drainage areas. Of course they are liable to error, due to not making the gaugings at a strictly ordinary low stage of the river, but they are believed to be approximately correct. In the case of the Menomi-

nee and the St. Louis rivers, where no actual measurements were obtainable, the discharge was estimated by comparison with neighboring streams. Both these latter have the greatest precipitation of the entire region upon their basins.

River.	Locality.	Estimated Ordinary Low-water Discharge per Sq. Mile of Drainage Area.
		Cubic Feet per Second.
Red River of the North	Mouth of the Pelican River.	0 416
	Breckinridge, Minnesota	0.217
Mississippi	Aitkin, Minnesota	0.340
Lower Fox River	Foot of Lake Winnebago	0.413
Saint Louis River	Mouth of River	0.400
Menominee River	Mouth of River	0.460

Mr. G. F. Swain, special agent of the census, who has written a report upon the water-power of the Atlantic States, kindly furnishes the following information:

"The ordinary low-water flow of the streams of the Atlantic coast without reservoirs, which have a rainfall of 50 inches per year, rarely exceeds 0.40 of a cubic foot per second per square mile of drainage area, while some with 38 to 40 inches of rainfall give only 0.30 of a cubic foot per second, in the same stage, as is the case with the Potomac River."

In the lake region of the Northwest, with a precipitation of less than 30 inches per annum, the ordinary low-water flow exceeds in some cases 0.40 of a cubic foot per second per square mile of drainage area.

What speaks more eloquently for the lakes of the Northwest than these figures? When a stream like the upper portion of the Red River of the North is observed year after year, and is seen to scarcely vary four feet in depth from the drought of summer or the chilling cold of a northern winter to the melting of the snow and ice in spring, and when one is told that a three-foot rise on the beautiful river of the Lower Fox is unusual, then it is that the true value of the lakes is appreciated.

In giving credit to the lakes we must not forget the influence of the swamps, which are mingled with them in Northern Wisconsin and Minnesota, in maintaining the flow of the streams. The moisture retained by the roots and thick, matted growth is dealt out gradually. It cannot be denied, however, that the action of the swamps is not entirely beneficial. The evaporation from their

luxuriant vegetation and the shallow, stagnant pools of water is enormous, while in cold winters they often freeze entirely solid, and then the flow from them ceases completely. For example, a person familiar with the Kankakee river, in Illinois, stated it as his opinion that the swamps at the headwaters of that river were of more injury than good to the stability of the flow. It is probable that in a moderately level country, with a rigorous climate, swamps alone are of questionable value, where a permanent water-power is required throughout the year; but deep-seated springs, where they exist, exert a greater influence in regulating the flow. With lakes the case is different. It is true that extensive evaporation takes place from their water surfaces—about 0.15 of an inch per day from April to October, inclusive, at the sources of the Mississippi —but their depth, as compared with their surface, is much greater than in swamps, and they usually receive the drainage from considerable areas, which is protected in their depths from evaporation; also in winter a covering of ice (three to four feet in Minnesota in the winter of 1880–81), protects the waters below from freezing, and thus a constant supply is given to the streams throughout the coldest weather.

It must not be supposed, that each one of the lakes in the region engaging our attention is filled to the brim by full-flowing streams, while a small river rushes through its outlet. From the very fact of their proximity to each other, the drainage areas of many must be extremely small; in fact, some have hardly more area tributary to them than the water surface which they expose to the rain and snow. Such lakes usually constitute a separate system of their own, and are of no value to the main stream in whose basin they lie. Other lakes receive a supply of water which is greater than their loss from evaporation and filtration, and these pour their tribute into the water-courses.

The lakes of the Northwest may be divided into three classes: 1. Those lying in the course of the main streams, being in a certain way expansions of their surface. 2. Those which have an outlet into the main streams. 3. Those without any visible outlet.

To the first class many of the important lakes belong, serving a most useful part in catching the surplus water of the streams and parting with it gradually, and often there are side streams and lakes directly tributary to them. In this connection it is proper to mention a peculiarity of some western streams, viz, in having lakes

tributary to them, which are connected by a short, sluggish channel with the water of the river. When the main stream is high, the water backs up in this short channel and fills the lake, to be let out gradually. Lakes which thus equalize the flow were called, in the language of the Chippewas, Pokegama, and several pokegamas will be noticed upon the maps of Minnesota and Wisconsin.

Of the second class of lakes, some give large additions to the volume of the rivers, while the outlets of others are only small brooks. No correct estimate of the importance of these lakes to the maintenance of the flow of the rivers can be gathered from their actual size; the extent of the area tributary to them must, of course, be taken into account. The following example illustrates this point: Mille Lacs, in Minnesota, has an area only 13 square miles less than that of Lake Winnebago, in Wisconsin, as shown by the figures in the table; but the area tributary to Lake Winnebago is 60,6 square miles, while the line of watershed limiting the drainage area of Mille Lacs is nowhere more than 6 miles from its shores. The result is that the broad channel of the Lower Fox is the outlet of the one, and the comparatively small stream of the Rum river drains the other.

Some of the lakes have a running stream leading from them, but on making their complete circuit no apparent inlet can be discovered. The surface drainage from the surrounding shores is insufficient to account for this. They are fed by springs in their beds, which beds are almost without exception in the glacial drift, which often contains layers of sand and gravel. To the presence of these water-bearing strata is doubtless due the existence of the springs. A land surveyor informed me, that, while his party was surveying in western Minnesota, in the winter, they came to one of these lakes, and, noticing in the distance a singular round hole in the otherwise unbroken ice surface, they went out to examine it. One of them, being too curious, broke through the edge, but managed to hold to the ice until assistance came, the force of the current of water being so great as to hold him out horizontally. This place was far removed from where the current at the outlet could have any effect.

Of the third class of lakes there is an immense number. Often they are small ponds, filling hollows in the land, but some of them are of considerable extent. There are two causes, one or both of which may operate to produce them, and these give rise to a sec-

ondary division of the third class, viz.: 1. Lakes having no outlet. 2. Lakes having a subterranean drainage.

To division 1 belong the lakes which have been already alluded to as having very small drainage areas. The supply of water which they receive does not suffice to raise their water-surface high enough for them to find an outlet (except perhaps in very wet seasons, when they come, for the time, under the second class), and they are really stagnant pools, in which the surface is lowered by evaporation. They merge into marshes and reed swamps, such as are found in large numbers in portions of northern Iowa. These lakes, of course, contribute little to the value of the water-powers.

Division 2 takes by far the greater number of the lakes of the third class, and as the water is usually comparatively pure, although the soil is rich in salts, it is fair to conclude that there are very few of them with absolutely no outlet, the same causes that have been mentioned as giving rise to springs in the lake beds, acting equally as well to give a means of outlet to the lakes. It is extremely probable that many lakes which apparently have no connection with the streams, feed them with a steady supply of water, which filters down through the sand and gravel, where these occur in their beds and banks. There are many probable examples of this. The area of Lake Minne-wa-kan, in Dakota, is 107 square miles. Although this lake is claimed to have no outlet, it is thought to aid the volume of the Sheyenne, a tributary of the Red River of the North. In some cases, the filtration may take place and the water be discharged at some distant point, thus being a positive source of loss to the volume of the streams of the locality. Nevertheless, it is fair to assume that most of the northwestern lakes exert a beneficial influence upon the water flow of that region; certain is it, that their entire absence would make a great difference in its steadiness.

In many cases it is entirely practical to raise the level of the lakes by dams at their outlets, and thus largely increase their storage capacity. The discharge could then be regulated at pleasure, and the permanency of the water-powers still improved. No surveys with this object in view have been made so far as known, with the exception of those carried on under the direction of Major Charles J. Allen, corps of engineers, U. S. A., for the reservoir system of the Upper Mississippi River, and a survey along the

Rock River of Illinois, for the same purpose. These demonstrate the feasibility of establishing artificial reservoirs upon the Upper Mississippi, which would much improve its navigation and be of great value to the water-power interests. The small cost of land makes artificial reservoirs comparatively inexpensive.

THE FIELD WORK OF A SURVEY FOR AN ELEVATED ROAD OVER A CROWDED THOROUGHFARE.

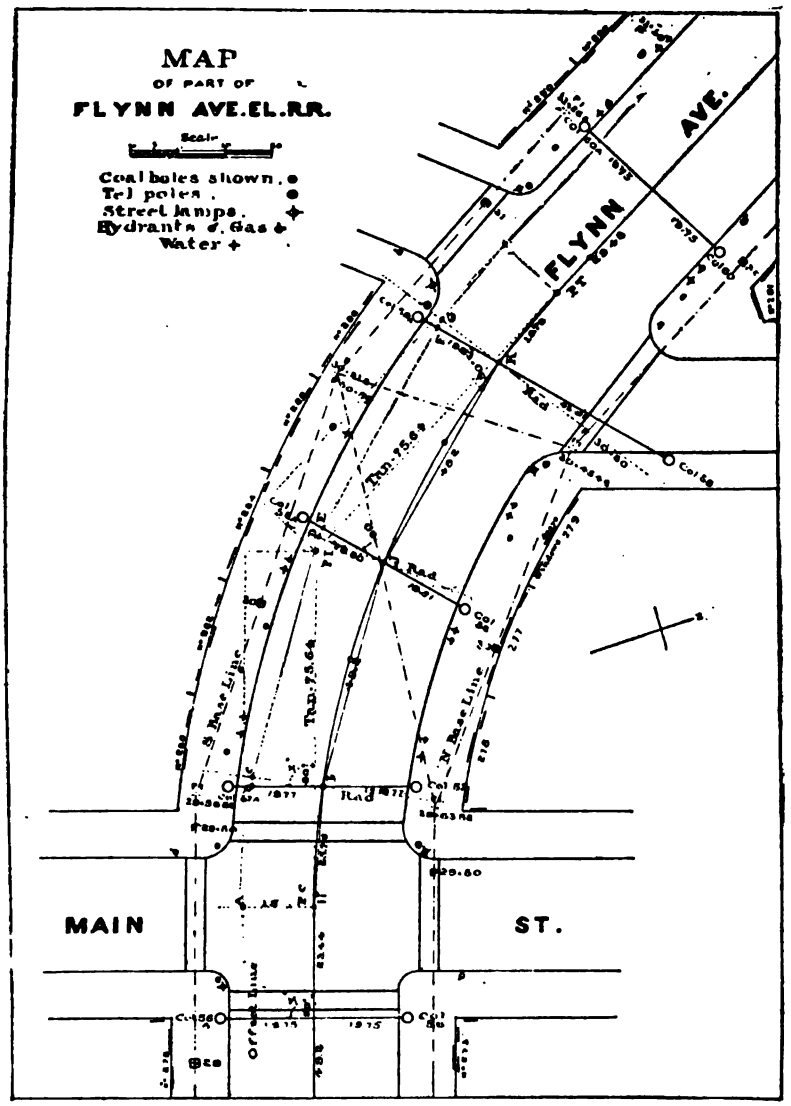
BY A. McC. PARKER, E.M.

THE actual location, in a crowded thoroughfare, of an elevated road spanning the street, presents, to the one first trying it, many new things in a line supposed to be thoroughly understood by boasting engineers.

Where one can see his lines and stakes, and can get over them with an instrument, curve and tangent location is not especially difficult, but where these lines require to be run in a crowded street, with a double line of street railroad tracks taking up a good part of it, the problem becomes far different. Under the given conditions it is almost impossible to get on your centre line. Then again all points have to be marked on Belgian-block or cobble-stone pavement, which appear, after an extended experience with them, to be made up of more joints than stones. The writer found that a plain cross scratched deeply on the stones with a finely tempered steel scratcher, about six inches long, tapered off to a long sharp point, was permanent and readily picked up, if properly referenced with four deep points made with a cold chisel. Six-inch wrought iron-spikes and 40 dy nails serve very well for the joints, the actual centre being pricked in with a sharp centre-punch.

Inasmuch as it is impossible to set up on the centre-line, all running must be done on offset lines parallel with the centre lines. Generally in elevated work a base-line is run on each sidewalk with all the accuracy attainable, and the more, the better for future work. From these base-lines the topography of the street is obtained. Everything should be noted, such as property-lines, doors, windows, lamp-posts, telegraph and telephone poles, gas- and water-caps, coal holes, awning-posts, curbs, receiving basins; in fact

everything that can be seen or heard of should be taken, and above all things, vaults and bake-ovens. These base-lines should be marked at every 50 feet, and at every point of intersection, with



distinguishing marks, cut in the flagstones. Full stations were marked $\overset{\text{P. I.}}{+}$ 175, plus stations $\overset{\text{P. I.}}{+}$ 175 + 50, and points of intersection $\overset{\text{P. I.}}{+}$ 175 + 59.78. All measurements were made with 50-

foot steel tapes carefully levelled and plumbed. I found the most convenient tape was one that was graduated from the end of the steel, as it enabled me to put a good stout handle through the ring without interfering with the bob, or being in the way when it was necessary to put the tape down flat on the sidewalk or pavement. A 75-foot tape should be kept handy for an occasional long measurement, and for the curve work.

To save endless trouble in the future, the first thing to be done should be the establishing of a number of standard 50-foot lengths along the lines to be surveyed, on water-tables or wherever they will not be disturbed. A careful description of these should be made and put up in a conspicuous place in the office. The mortality of steel tapes on such surveys is surprising, and the variation in the lengths of 50-foot tapes, religiously marked U. S. Standard, leads one to believe that we must have a very fickle government. Any time spent at the outset on such standardizing work will be time well employed. When a new tape comes on the work, compare it at once with the standard and find out its correction.

After these preliminaries are carefully looked after, one can begin the survey, work up the maps, and turn them over to the higher powers for their studies and the projection of the location. The next step is to put this location on the ground. The tangents having been spotted on the maps, they must be extended to intersections with the sidewalk base-lines, and the plusses of these intersections scaled off. These plusses can then be laid off on the ground and the tangents tried to see if they are satisfactory.

The P. I. of curves, except for a very small central angle, will come outside of the car tracks, and the instruments can generally be set up on them and the angles measured directly on the tangents. After fixing a P. I., I found it saved time to fix the P. C. and P. T. at once. These points are set from the P. I., are marked to stay, and the curve must check out on them exactly (to, say, one hundredth). We must next get on a tangent parallel with our tangent and at some convenient offset from it, say 15 feet, and fix our P. C. and P. T. on the offset tangents. I found it handiest when set up on the P. I. to turn off 90° from both tangents and run out the offset distance, setting points. I would then set up on the point at right angles to the initial tangent and turn to the similar point set at the other end of the initial offset-tangent for a

back sight. I would then run back on this line the tangent length and fix my point. I would then set up on this point, turn 90°, run 15 feet and check up my P. C. of the centre line. I next would determine the plus of the P. C. from the last station set on the tangent, and we will assume that it came at 29 + 47.32.

In elevated work in iron or steel, where the structure is carried on columns, set in the sidewalk, supporting transverse girders

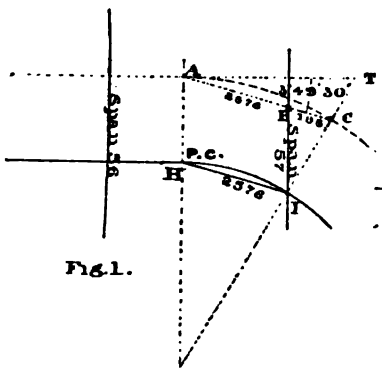


Fig. 1.

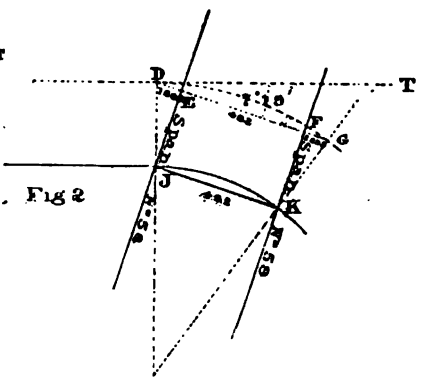


Fig 2

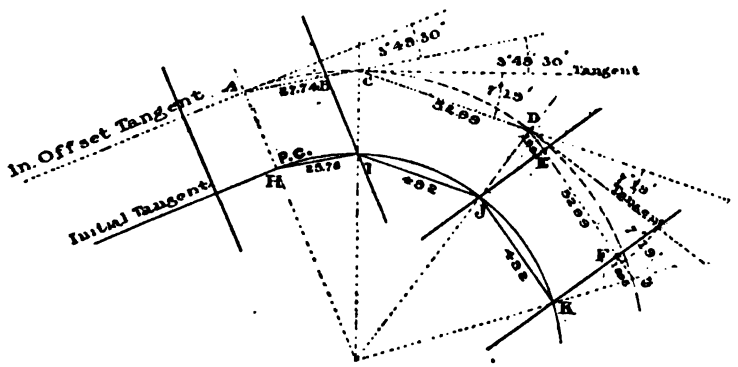


Fig. 3.

which in turn carry the longitudinal girders, it is desirable, for reasons of economy in shopwork, to get as many spans of the same length as possible, and also on curves to arrange the transverse girders in pairs parallel with each other, or else, in the case of long sweeping curves, to arrange them all radial. It is also customary in this kind of work to fix the pairs of transverse girders so that each alternate pair of girders will be rigid, throwing

the contraction and expansion into each alternate longitudinal span. For short curves it saves shopwork to divide the transverse spans into parallel pairs, leaving the longitudinals of the same length in alternate spans, and throwing the variation in length of longitudinals in the intermediate connecting spans. In the case about to be illustrated, we will suppose we pair them, that the first transverse span on the curve must pair the last transverse span on the initial tangent, and with the longitudinals form a fixed span. We will also suppose that the last transverse on the tangent came at sta. 29 + 23.88 of the centre line, and that our spans are 49.2 feet. The plus of our first point on the curve is therefore 29 + 73.08. Our P. C. is at 29 + 47.32, and consequently of our 49.2 foot span, 23.44 foot is tangent and 25.76 curve. We will assume that our offset tangent lies outside of the curve. Never try to work in a curve where you want to run it to hundredths of a foot, by using the curve name. Always work from the radius and calculate each deflection angle from the length of the chord to be taken. We will assume that we are about to put in a so-called 30° curve to the right, and that our angle of intersection is 42° 26′. This curve is one in which a chord of 100 feet subtends an angle of 30° at the centre of the circle. According to a well-known geometrical principle the radius is equal to one-half the chord—divided by the sine of ½ the angle subtended by the chord. Conversely, for any short chord the sine of ½ the angle subtended is equal to ½ the proposed chord divided by the radius. As ½ the angle subtended is the deflection angle for the chord, we get at once what we want for our work.

We will now assume that we have gotten all the preliminaries finished and that we are set up on the P. C. of the offset curve with the instrument set at 0° in the line of the offset tangent. Our P. C. is at + 47.32. Our first point to be located is therefore + 50. Inasmuch as the underlying principles are the same in both cases I will not describe the location of the + 50, but go at once to the first transverse span, which comes at + 73.08, a distance on the centre line curve of 25.76 feet from the P. C.

By our rule—sine of deflection angle $= \frac{25.76}{2 \times 193.185} = \sin\ 3°$ 49′ 30″. For the reason that the radius of the offset curve is 15 feet longer than the radius of the centre line curve, our chords on

the offset curve must be increased proportionately, and our constant will be $\frac{193.185 + 15}{193.185} = 1.077$, if we are to locate points on the offset curve that shall be on radii through corresponding points on the centre line curve. If we now deflect 3° 49′ 30″ R. and run 25.76 feet, we will be running a curve parallel with our centre line curve, but if we run 25.76×1.077 feet, we run on a curve concentric with our centre line curve and with a radius 15 feet longer. The first distance lands us at B (Pl. 1, Fig. 1); the second, at C. We must fix both these points. If we now set up on B, take a back sight to A and turn to 90° on the plates, we will be on a line at right angles to our tangent and parallel with span 56. If we now run 15 feet N., we fix the end of our longitudinal on the centre line. We now run out to the curbs, N. and S., and locate cols. 57, 57A, to our satisfaction, and record the distances from the centre line to the cols. We also intersect both base-lines, and measure distances from centre line to the points of intersection, and also their plusses, for calculations in the office.

It is also well to measure the angle the transverse span makes with one or both of the base lines. We now set up on C (Pl. 1, Fig. 3), and get on the tangent at that point. Our next deflection is determined, $\frac{49.2}{2} + 193.185 = \sin 7° 18′ 56″$, say 7° 19′. To fix D on the radius D. J., we must run from C. 49.2×1.077 feet $= 52.99$, because we are now running on a curve of 208.185 feet radius. This distance brings us to the point D. We then move up to D, get on tangent and deflect 7° 19′ and run 52.99 to G. Spans 58 and 59 (see Fig. 2) are to be parallel and at right angles with the chord. We are now set up at D and turned to G. Our chord is 52.99 on the offset curve, and 49.2 on the centre line curve. If we come back from G ½ the difference in chord lengths, we will fix F and then by setting up on F we can fix E and lay out span 59. Then setting up on E, we can lay out span 58. We now find out from G (see Pl. 2), that to the P. T. is not long enough for a full span, and we must next proceed to find out how long it is. In running curves exactly, it does not suffice to divide the central angle by the degree of the curve, to find the length of the curve. The actual length of the curve in chord units will depend on the length of the unit chord. The shorter the chord the more nearly the chord-curve approximates the arc of the circle, and the longer the

chord-curve will be. Hence at this point we must figure up how much of our central angle has been consumed and then calculate what remains of the curve. By consulting Fig. 3, Pl. 1, we find we have used up 36° 55′, leaving 5° 51′. One-half of this, 2° 55′ 30″, will be our final deflection angle. We must next find the length of the corresponding chord. By our rule conversely, it is 2 Rad. × sin. def. angle, = 19.72 feet in this case. We must multiply this by our ratio to get our offset chord = 21.23 feet. If now from G, being in tangent, we deflect 2° 55′ 30″ and run 21.23 feet, we will reach the P. T. on the offset curve, which should be a point at right angles with the P. T. on the centre line curve and 15 feet distant from it, thus checking the work. We find then that our curve is 143.88 feet long. By the rule, the length = central angle ÷ degree, it would be 142.55, showing the very material difference in length due to the use of short chords. The actual arc length is 144.19.

For convenience in plotting profiles and in grade calculations, it is necessary to have elevations of stations and plus 50s on the centre line, and consequently all full stations and plusses must be run in addition to the transverse span centres, but I would advise that these points be not marked permanently until it is certain that no further change will be made in the alignment, because a change in length of any longitudinal span, that comes on a curve, will shift every full station and plus that follows it, and change the length of the centre line, requiring the changing of every point set, if continuous stationing is required.

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BOOK REVIEWS.

TREATISE ON DETERMINANTS (Revised Edition). By William G. Peck, U. S. M. A., Ph.D., LL.D., Professor of Mathematics and Astronomy in Columbia College. Pages iv., 69.

The science of Determinants has been of slow growth, for nearly two centuries have elapsed since its fundamental idea was suggested by Leibnitz, the inventor of the Infinitesimal Calculus. The conception of Leibnitz was not wrought into a system until the time of Vandermonde and Laplace in 1771, nor was it then sufficiently developed to be used as a means of investigation. In the early part of the present century Cauchy took up the subject, and in 1821 gave it a place in his Course of Analysis for the Polytechnic School. Jacobi introduced it into his memoirs, and finally, in 1841, he published the results of his study in what Muir styles "a masterly monograph." Since that time the method of Determinants has been extensively used in analysis, and especially by Cayley and Sylvester, in whose hands it has been made a powerful instrument of research. Within the last forty years many valuable treatises on Determinants have been published, but these are, for the most part, too abstruse and too voluminous for the use of the general student who only seeks for a sufficient knowledge of the subject to enable him to keep pace with the progress of modern analysis. This difficulty seems to have been removed by the little work before us. The author has condensed into about 70 pages the definitions and leading principles of the subject, and has found space for a suitable number of examples and practical illustrations. The book appears to be well fitted to fill the place for which it was intended—a text-book for colleges and schools of science.

J. K. R.

GRIMSHAW'S PUMP CATECHISM. Practical Publishing Co. New York, 1888. Copyright, 1886. 223 pp. 32mo. $1.00.

This book is aimed at those with limited general advantages and without other facilities for acquiring the knowledge which will enable them to take responsibility in care of steam plants. It is not directed at educated engineers, and yet even to such the special information might at some time be found very useful. The catechetical form is, perhaps, best adapted for the class of men whose times for study are often inter-

rupted, or by whom a categorical answer to a pointed question is more easily retained and assimilated. But, except in the most capable hands, the adoption of the catechetical idea is apt to result in *superficial* treatment of questions. The answer is intended to be short, or else the pointedness of it is lost: if short, it can rarely be made exhaustive.

The scheme of the book is a judicious one. It begins with a description of all the usual types of pump—and includes some unusual ones. Then the questions of suction and forcing, of piston and plunger, and of fly-wheel and other mechanisms, are treated, with a section on types of water-valves. The discussion on lengths of suction-pipe, and friction in pipes, length of draft horizontally, etc., is specially sound, and brings together a good deal of valuable experience in these questions. The descriptive parts are mostly compiled from reference sources open to easy consultation. These sections occupy 44 pages, with frequent illustrations.

The section on Design and Construction is good (20 pp.), discussing matters of long and short stroke, lift of valves, arrangement of piping. Also the Section on Care and Use (12 pp.) contains much which a tyro can very profitably examine. But the bulk of the book (from pp. 76 to 204) is taken up with a series of reproductions from matter already in print elsewhere, giving the details of interior construction and methods of assembling the parts of the special makes of pumps in the market in 1886. To one familiar only with one maker's pump it may be convenient to bring together between the covers of one book what he could otherwise secure only from a number of catalogues, but it is quite questionable whether any one who had to take apart and put up a pump of a special make would not prefer to refer to the larger and clearer views of a maker's publication, and to use the lists of parts which he gives, rather than to depend upon the reductions which appear herein as illustrations. Moreover, to avoid any appearance of favoring one builder more than another by a first place in the discussion the pumps are treated alphabetically, like the "ads." in a daily newspaper, with no attempt to classify them into groups according to any logical scheme of study. Hence a regretable confusion and occasional prolixity results, which could have been avoided if more of author's editorial digestion of material had been used. The author makes no secret of his indebtedness to the makers of the various pumps for the material which he publishes, and lets it be understood, that, where the treatment is not as copious in any case as for others, it is because the maker did not respond as fully (p. 203). It would have been better for the author to have been less in a hurry to bring out his treatise, and to have supplied from his own skill and experience the help which he sought to give, as he says in his dedication, "To every one who wishes to know more to-morrow than he did yesterday." This part of the work lays it open to the charge of being prepared rather to add to a list of publications than to have been the result of an author's conviction that the result of his toil and study ought not to lie unfruitful of good to others because of his silence.

The concluding pages of the book are taken up with miscellaneous matter as to duty of pumps, pumping hot and cold water, etc., followed by illustrations of the usual calculations about pumps, and tables of areas, roots, reciprocals, and logarithms of numbers from 1 to 100, and the functions of π.

While, therefore, the reviewer finds much in the book to commend, and which gives it interest and value from a practical standpoint, yet he rises from reading it with a sense of disappointment that it is not better. The talent and ability of the author, coupled with his skill in special lines, ought to have resulted in a treatise of more value, in spite of the disarming avowal of the preface that it is not intended for professional men. Even the operative mechanic would profit more if the matter of the book had been better arranged, less superficial in places, and more thoroughly digested before the publication was made. F. R. H.

THE LIXIVIATION OF SILVER-ORES WITH HYPOSULPHITE SOLUTIONS, WITH SPECIAL REFERENCE TO THE RUSSELL PROCESS. By Carl A. Stetefeldt. Published by the Author. 18 Broadway, New York. 223 pages and 2 plates. Price, $5.

This treatise contains the two already published papers of the author in the *Transactions* of the Institute of Mining Engineers in a modified and thoroughly revised form. In addition he introduces much new matter, based on data since obtained in practice and in the laboratory. Where the author embodies material of other writers on the Russell Process he takes occasion to correct some of their inaccuracies and mistakes, and explains some of their obscurely expressed ideas. For this the author deserves the thanks of the profession.

The appearance of the book is tasty and the print is good. The whole subject has been arranged and grouped in a systematic manner, and is critically discussed in two parts. Part I. discusses the chemistry of lixiviation in 97 pages. Part II., its practical execution in 113 pages. Thirty drawings are introduced in the text.

A short ten-page introduction recites the history of lixiviation, points out the defects of the old lixiviation process, compares the Russell Process with amalgamation, and briefly describes ores suitable for lixiviation, etc.

No attempt is made to discuss the operations preceding lixiviation—crushing and roasting—since they are the same as in amalgamation, are sufficiently known, and would require a separate treatise.

But when, on page 9, Ontario and Daily ores are cited as exceptions to the general rule of ores permitting coarse crushing to be followed by successful amalgamation, because the coarse sands the settlers work off, besides allowing the quicksilver and amalgam to settle, are comparatively valueless; it must not be forgotten that this very same character of the ores—the precious metal-bearing minerals being themselves massive, crushing easier than the associated quartz which in itself is poor—makes them also a type of ores pre-eminently fitted for leaching.

Throughout Mr. Stetefeldt's book he states theoretical and practical problems lucidly, and in his discussions there is no room left to misunderstand him. This will certainly invite those especially engaged and interested in lixiviation and its chemistry to a close scrutiny of some of the reactions, and it may eventually lead to a clear understanding of the whole subject.

The Russell Process, as far as its more energetic dissolving and decomposing action is concerned, is an improvement on the simple sodium hyposulphite lixiviation. A discussion of the former entails that of the latter, and the author bases the title of his book on this fact. In Part I., Chapter II., pages 18 to 34, the reactions of hyposulphite solutions applied to metals and various compounds are stated. Here ten new sections are added to the material of the author's former publication.

The statement of the author on page 23, § 213, that the silver of silver ores containing arsenic and antimony, after chloridizing roasting, is more amenable to extraction by lixiviation than by amalgamation, is probably partially conditioned by the degree of perfection with which the ores have been roasted, as is indicated by the author's own remarks on extraction of silver from certain tailings in the same section. The amount of insoluble silver arsenate and antimonate left in tailings has probably been rarely determined as such.

Part I., Chapter III., pages 35–62, discusses the reactions of "extra solutions" in full, and cites practical examples showing the increase in the amount of silver extracted. There are five new paragraphs in this chapter. With auriferous silver ores, after chloridizing roasting, the Russell Process can hardly claim so far a higher gold extraction than amalgamation, especially not should the gold be coarse. The nature of the roast required for the two metals is too different to allow, with our present knowledge, a high extraction of both metals. It also depends on the character of the ore, whether or not heavy chlorine generating metals are present or not.

The chemical facts presented by the author, in his discussion of decomposition of extra solutions by atmospheric influences at ordinary temperature, are new and of interest.

Chapter II., on the chemistry of the wash-water, contains three new sections, besides reviewing the investigations of various authors on the solubility of silver chloride in brine, etc.

In Chapter VI. the author presents, in 16 pages, his thorough investigation on the chemistry of sodium and calcium sulphide. He discusses the theories of high precipitating coefficients.

Chapter VII. contains 20 pages on laboratory work, which are well written, entering freely on the question of testing the ores, and concluding the theoretical part of the treatise.

The second part of the book is devoted to the practical execution of lixiviation. It gives a full description of the lixiviation plant, with a series of detail drawings; in it are described its operations and the solutions used in the same, also a new apparatus for the precipitation of silver from the wash-water. The discussion of the lixiviation of raw ores, acid roasted and alkaline roasted ores, is followed by the author's opinion on trough lixiviation.

Then the author takes up the precipitation of the metals from a lixiviation solution and the refining of sulphides.

The chapter before the last treats on mill construction and the expense of running a lixiviation-mill. This chapter is full of valuable information as to costs and weights, and happily the costs are given in days' work, quantities of supplies, etc., so they can be applied under different conditions.

It is a pity that, after Mr. Krone's rolls are so long in the market, it is as yet impossible to obtain reliable data and statistics as to their capacity and the power they require. Even Mr. Stetefeldt is left in the lurch in his chapter on "Capacity of Krone's Rolls," etc.

Of the book as a whole we must say that it is ably written, and presents a typical model unique in clearness, thoroughness, and valuable statistics. It is the only treatise on the subject, and indispensable to the student. C. M. R.

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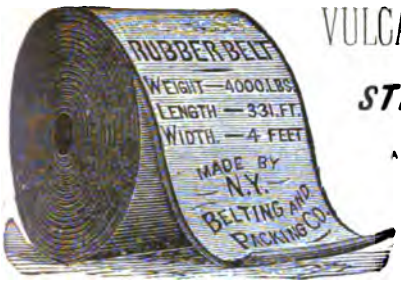

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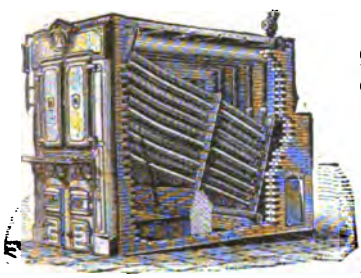

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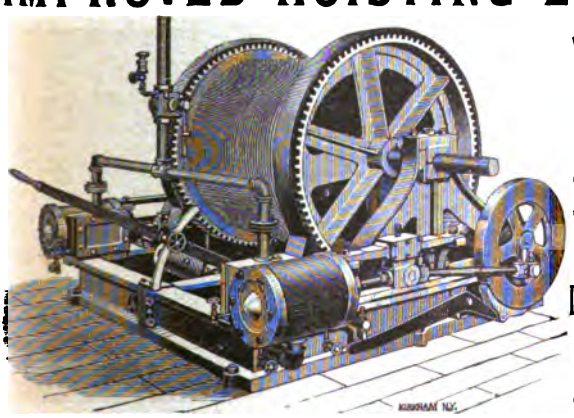

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THE

SCHOOL OF MINES QUARTERLY.

VOL. X. JANUARY, 1889. No. 2.

THE OIL FIELD OF COLORADO.

BY PROF. J. S. NEWBERRY.

THE newly opened oil field of Colorado is located in the valley of the Arkansas between Pueblo and Canon City; most of the wells being near Florence, eight miles below Canon City. Petroleum was discovered here many years ago issuing from the ground, and one or two wells were bored between Florence and Canon City. The yield was, however, not large, and there was no market for the product; so the enterprise of oil production was permitted to lie in abeyance until two or three years since. Now some thirty or forty wells have been bored, and the production of those worked is about a thousand barrels a day. Nearly all the wells have yielded oil, but some of them only two or three barrels a day, while the largest amount taken daily from any one well is about one hundred barrels. The average of the wells now worked is about fifty barrels a day; a larger yield than that which obtains in the oil field of Western Pennsylvania, the most productive on this continent. There are no fountain wells in the Arkansas oil field, because the strata contain no cavities in which oil and gas could accumulate until tapped by the drill. "Gushers," or fountain wells, only occur where sandstones and shales alternate, the first by their open joints and pores serving as reservoirs; the latter as impervious covers by which the current secretion is confined.

Geological Structure.

The geology of the country about Florence is very easily read. The Arkansas valley is here bordered by rocks of the Laramie group—sandstones and shales with beds of coal—lying nearly horizontal. Important coal mines are opened and worked two miles south of Florence; the output, which is large, being known as the "Canon City coal," and ranking as rather the best of all the coals taken from the eastern coal belt of the State, at Trinidad, Walsenberg, Golden, Erie, Marshall's, etc.

At Florence the Laramie group is cut through, exposing the upper portion of the Colorado group, the middle member of the Cretaceous system. This formation has here a thickness of over three thousand feet, the upper portion consisting of earthy limestones, the lower of black shales, which have a thickness of at least two thousand feet. The oil all comes from these shales. One or two wells have been carried to the depth of three thousand feet, but the most productive oil horizon lies between one thousand and fifteen hundred feet below the surface. Further up the valley all the sedimentary strata are uplifted and rest against the granitic axis of the Greenhorn range of the Rocky Mountains. Here we find the three members of the Cretaceous—the Laramie, Colorado and Dakota groups—followed below by the Atlantosaurus beds of the Jurassic, from which Prof. Marsh has obtained the bones of *Atlantosaurus* and other gigantic reptiles. This is a fresh-water deposit; the Saurians were terrestrial, and with their bones occur great numbers of the shells of Unios.

Below the Jurassic come the red beds of the Trias, then Carboniferous limestones and a great series of highly metamorphosed slates, which probably represent the Cambrian system. These are fully exposed in the cañon of the Arkansas called the Royal Gorge, which is mostly cut in the granitic axis of the mountain range. North of Florence rises the southern extremity of the Front range of the Rocky Mountains, here forming a bold headland crowned by the summit of Pike's Peak.

Quality of the Oil.

The petroleum of the Colorado oil field is brown in color, has a gravity of 30° to 31° Beaumé, and an odor which is much less pungent and disagreeable than that of the Pennsylvania oil. On

distillation it yields 40 per cent. of "water-white," almost odorless, and excellent burning fluid. The residue is thick and oleaginous in consistence, and contains so much paraffine that it chills and thickens at the temperature of zero. It is an excellent lubricator, which in the eastern markets would command a high price. In Colorado there is no sale for it as a lubricator; the market being supplied and monopolized by eastern lubricators sold through the Standard Oil Company. At Florence many thousand barrels of this lubricating oil are stored, waiting for the time, which is sure to come, when a free market will be opened to it, and it will be the most remunerative product of the wells. Now it is only used for fuel, a purpose which it serves admirably, but for which it is quite too good. It is burned under the stills of the refineries and in the stationary engines which pump the wells. It is thrown into the fire box with a jet of steam, and exhibits all the excellences of a gaseous fuel, emits great heat, is instantaneously lighted and cut off, does no harm to the boilers, and leaves no residue.

Area of the Oil Field.

At present the limits of the Colorado oil field are undetermined. Wells bored near Pueblo, forty miles down the river from Canon City, yield water abundantly, but no oil. On the north and west the field is certainly limited by the metamorphic rocks, from which no oil can be obtained. Towards the south quite a stretch of country has the same geological structure, and the oil field may extend some distance in this direction. Just how far down the river from Florence the productive wells may be extended has not yet been learned, but the Union Oil Company, which owns most of the wells at Florence, controls fifty to sixty thousand acres in this direction, and it seems probable that much of this territory will be found to be productive. The bituminous shales of the Colorado group, which are evidently the source of the oil, underlie a wide belt of country along the eastern base of the Rocky Mountains, but on the west they are turned up on edge and much broken, so that their carbonaceous matter has been distilled and the volatile products have escaped. Towards the east the shales rapidly become calcareous and are represented by limestones, the deposits of the open sea. It is only as we approach the old shore of this sea, on the west, that its sediments become shales, composed of

sand, clay, and carbonaceous matter. It is, therefore, along this zone, intermediate between the mountains and the plains, that oil fields will be found in places where the shales have been somewhat affected by the proximity of the crystalline rocks and yet have not been too much disturbed and broken.

Other Oil Fields in Colorado.

From the western base of the Rocky Mountains the rocks of the Cretaceous system stretch away westward to, but not beyond, the Wasatch. Here the Laramie group is three thousand feet in thickness, and contains a series of coal beds, which will compare favorably in purity, variety and thickness with those from any other coal area in the world. Beneath the Laramie the Colorado group consists of bituminous shales fifteen hundred to twenty-five hundred feet thick. These have been much disturbed in the vicinity of the mountains, and gas and oil are found issuing from them in many places; as on the north branches of the San Juan river, in "Coal Basin" below Glenwood Springs, and in the White river country. In this latter district oil and gas springs abound, and a vast quantity of volatile hydrocarbons have been driven out of the shales in former times, as is proven by the great deposits of Albertite (old Asphalt) found in the fissures of the overlying rocks. Some of these fissures are of great extent, one being reported to me as having a length of four or five miles, a maximum width of twenty feet, and everywhere filled with Albertite. Another similar vein two miles away is eight feet in thickness, and others still three feet and less. On the line of the Denver and Rio Grande Railroad in Utah, at Castle Valley, Pleasant Valley, Soldier's Fork, etc., the Laramie rocks contain important coal beds, and the bituminous shales below have yielded large quantities of petroleum. This in most cases has produced by evaporation and oxidation Asphalt and Albertite, in other cases Ozokerite; a difference doubtless due to differences in the organic matter from which the petroleums were derived. It is probable that these residual products of the liquid hydrocarbons evolved from the shales, will in the future become important items of export from this region. Whether productive oil fields will be found in the region west of the Rocky Mountains remains to be determined by experiment, but since the geological formation is the same over a large area between the Rocky, the Wasatch and Uinta Mountains, the possi-

bility of finding places where oil can be obtained in paying quantity should be borne in mind by those who are explorers in or have become residents of that country.

Genesis of Petroleum.

The facts observed in the Colorado oil field, as well as in the country west of the Rocky Mountains, afford important confirmation of the theory of the genesis of petroleum announced by me in the "Rock Oils of Ohio" in 1859, and reiterated in my reports on the Geology of Ohio, and in the article on the Origin and Relation of the Carbon Minerals, published in the Annals of the New York Academy of Sciences, vol. ii., No. 9, viz., that it is of organic origin, is derived by spontaneous distillation from accumulations of carbonaceous matter, as coal, lignite, bituminous shale, and bituminous limestone buried in the earth; that marsh gas and petroleum are found issuing in greater or less quantity from all such accumulations of solid hydrocarbons, and that no considerable quantity of petroleum or marsh gas is known to exist in areas occupied by volcanic or metamorphic rocks.

The chemist, Berthelot, suggested the possibility of the formation of petroleum by the contact of carbonated waters with accumulations of oxidable metals in the earth, but never stated that any instance was known of the formation of petroleum by such a process. (*Annales de Chemie et de Physique*, vol. ix., p. 481.) Mendelejeff, however, has claimed that the petroleums of Pennsylvania and Canada are of inorganic origin, because, as he said, no accumulation of organic matter is known from which it could be derived. (*Revue Scientifique*, 1877, p. 409.) Whereas American geologists know that the respositories of petroleum in Western Pennsylvania are immediately underlain by Devonian bituminous shales, five hundred feet or more in thickness, and that gas and oil springs mark the line of outcrop of these shales from New York to Tennessee. So, a series of oil deposits are found connected with the bituminous limestones and shales of the upper part of the Lower Silurian System in Canada, Northwestern Ohio, and about Burkesville, Kentucky. The oil wells of Mecca and Grafton, Ohio, and a line of gas and oil springs are associated with the Cleveland shale, a carbonaceous stratum fifty to one hundred feet in thickness, which lies at the base of the Carboniferous system in Northern Ohio. Finally, we have another im-

portant oil horizon in the carbonaceous shales of the Middle Cretaceous in Colorado and Utah. Thus we are able to connect all our important deposits of oil and gas with underlying strata containing large quantities of carbonaceous matter; and no considerable accumulation or emission of oil or gas is known in this country apart from such relationship. So much for positive evidence! The negative evidence is hardly less conclusive, as no oil or gas has been found in or issues from our great areas occupied by metamorphic or volcanic rocks; though the conditions would seem to be specially favorable there for the production of petroleum by Berthelot's process. That is, the strata are much broken up, and carbonated water (*i.e.*, all rain water) would easily penetrate the earth, and would reach a heated zone at a less depth than elsewhere. From the metamorphic rocks of the Alleghany belt, New England, the Adirondack, and the Laurentian highlands no gas or oil escapes, though there the strata are upheaved and broken, and water would easily sink through them.

The reason for this state of things is simply that the organic matter of these old sediments has been thoroughly distilled, and its volatile constituents have been driven off. We find graphite in abundance in the metamorphic rocks, and this is the residue from the complete distillation of organic matter.

Mendelejeff is reported to have recently produced petroleum artificially and synthetically. This is an interesting fact, but one that probably has no bearing upon the occurrence of petroleum in nature. No one would be justified in denying that the Almighty *could* produce petroleum by a combination of inorganic elements, but that He *has not* done so is indicated by all the facts known to geologists.

PATENT PROCESSES.

BY EMIL STAREK.

A DISCUSSION of the present paper, the subject matter of which is indicated by the above title, would hardly be satisfactory without a brief reference to what was said on the subject of patent claims in an article by the writer in the January number of the *Railroad and Engineering Journal* of last year. It was stated that

all inventions can be divided into (1) Inventions in Structure, comprising (*a*) mechanical construction and (*b*) composition (either physical or chemical), and (2) Inventions in Method or Process. Whatever is considered patentable under mechanical construction is now generally expressed and claimed under "combinations" of mechanical elements, viz.: combinations in the sense of the patent law, that is, "a union of mechanical elements involving such a co-ordination of individual functions as to constitute a common function." As an example, under combination was cited the connecting rod on a locomotive, and reference made to the relation it bears to the mechanical elements with which it is immediately associated.

The above definition of combination, although framed from a mechanical standpoint, is nevertheless applicable to the class of inventions referred to as compositions (of matter). The familiar example of alloys will serve to illustrate the pertinency of the definition in that connection. The alloys of bell metal, phosphor-bronze, etc., each of which is composed of individual metals, so *combined*, however, as to react on each other both chemically and physically, thus producing a composition of matter new and useful, and wherein the function of each individual metal is so co-ordinated as to constitute a common function. The relation which any one ingredient of either of the alloys referred to bears to the remaining ingredients could be made manifest by simply removing such ingredients and observing the effect it would have upon the alloy in question. Prior to the intermixture each metal subserved some useful, original, individual function; but such function was modified after combination; hence the co-ordination of function referred to in the definition. If instead of an alloy we imagine a mass of lead, broken brick, pebbles, clay, etc., cemented together into one chaotic mass without any actual chemical combination, such a mass would simply be a body of juxtaposed materials, combined in no specific order, and according to no rational formula, a simple conglomeration. The brick, the clay, the pebbles, and the lead would all retain their original properties, unqualified one by the other, and any one could be removed from the mass without affecting its remaining elements. The mass in question would not be regarded as a composition, there would be no co-ordination of functions—a simple aggregation. The difference between

either of the combinations under consideration and aggregation is thus at once apparent.

The example chosen, although perhaps a little strong to illustrate a point clearly obvious to those familiar with the subject, was selected to make the distinction conspicuous. A more practical example and one presenting a mechanical unit whose elements are all operative would be an ordinary steam heating system including boiler, steam pipes with the necessary traps and pressure indicators, to which some particular or specific thermostatic device or pressure regulator valve has been attached. It is evident that the pressure regulator valve could be detached from said system without in any wise affecting the function or operation of either the boiler, the pressure indicator, traps, etc., or the pressure indicator might be detached without in any way affecting the operation of the regulator valve. In other words, each acts *independently* of the other; there is no immediate relation. This independence of action is the true test of an "aggregation," whereas, in a "combination," a removal of one of the elements would at once modify the action of the remaining elements, and this by virture of the co-ordination of function existing in a combination.

With a clear conception of what constitutes a patentable combination, what an aggregation, and what a composition, and, from the analogy which it will be shown exists between the relation of the individual elements of a combination, and the successive steps involved in the formation of a patentable "process," we can better proceed to the consideration of the latter, which is to form the subject-matter of the present paper.

To clearly understand what a process is, it might be well to establish what it is not. All processes require machinery and tools to carry them out; but not every machine operates or is constructed to carry out a process. A machine (defined from a mechanical standpoint) is a contrivance which transmits an extraneous force from one point to another; *i.e.*, from the point of application of the power to the point of effect. The transmission is evidently the result of the relative juxtaposition of the various elements constituting the train of mechanism, and the result due to such transmission is made obvious by the effect produced in the body operated on. As it is our intention to define the meaning of the term "process," and as every process contemplates the modes or

the manner by which one form of matter is transformed into another (physical or chemical), and inasmuch as every process requires some machine to carry it out, it will be necessary to consider only those parts of the machine by which the changes on the material in question are wrought. It will be our endeavor to demonstrate that the "process" as contemplated by the patent law is one that has an existence independent of and apart from any machine which carries it out. A brief review of one of the early decisions on this subject, Corning *vs.* Burden, 15 Howard, 1853, would be pertinent in this connection.

The case referred to was brought up, by writ of error, from the Circuit Court of the United States for the northern district of New York. The action was brought against Corning & Winslow by Peter A. Burden, as assignee of Henry Burden, for a violation of a patent granted the latter as the original and first inventor and discoverer of a new and useful machine for rolling puddle balls or other masses of iron in the manufacture of iron. Under the instructions of the Circuit court the jury found a verdict for the plaintiffs, upon which the defendants brought the case up to the Supreme Court of the United States by writ of error. Burden's patent was for "a new and useful machine for rolling puddlers' balls and other masses of iron, in the manufacture of iron." The language of the claim was in the following terms: "The preparing of the puddlers' balls as they are delivered from the puddling furnace, or of other similar masses of iron, by causing them to pass between a revolving cylinder and a curved segmental trough adapted thereto, constructed and operating substantially in the manner of that herein described . . . . or by causing the said balls to pass between vibratory or reciprocating curved surfaces, operating upon the same principle, and producing a like result by analogous means." It will be observed that the language of the claim is equivocal, and the claim, instead of being worded to set forth any definite machine or process, is stated by the introduction of a number of participles indicative only of the operation of the machine intended to be described. It was on account of this equivocal language of the claim that the court below charged the jury that, "The letters-patent which have been given in evidence by the plaintiff are for a new process, mode or method of converting puddler's balls into blooms by continuous pressure and rotation of the balls between converging surfaces,

thereby dispensing with the hammer, alligator jaws and rollers, accompanied by manual labor, previously in use to accomplish the same purpose; and the said letters-patent secure to the patentee the exclusive right to construct, use, and vend any machine adapted to accomplish the objects of his invention, as above specified, by the process, mode or method above mentioned."

Now, the language of the claim fully discloses the operation that the "balls" must undergo in order to produce the finished product. They must pass between two surfaces, either (1) "between a revolving cylinder and a curved segmental trough," or (2) "between vibratory or reciprocating curved surfaces." In this connection let us consider the operation the same balls had to undergo when produced by hand and the necessary adjunctive devices, as tilt hammers, alligator jaws, nobbling rolls with eccentric grooves, etc. It is clear that the iron product made by the use of these machines, had also to undergo *pressure between surfaces*, more or less curved. Whether that pressure was continuous or intermittent, as a result of percussion, is immaterial. *Pressure* was necessary, otherwise the expulsion of slag and cinder would have been difficult or perhaps impossible. Comparing, therefore, for the sake of argument, the Burden patent with the tilt hammer, we observe that the *operation* which the ball undergoes for the time it is acted on by the machine is the same—that of *pressure*. On the one hand the pressure was continuous, on the other, intermittent, the rolling of the ball necessary to a perfect expulsion of the cinder being done by hand in the latter case. Whether the bloom is operated on by the cylinders, the tilt hammer or alligator jaws, the only process involved in the operation in any case, is the *process of compression* which the bloom undergoes while being treated. The term "process," in this case, is "used subjectively or passively as applied to the material operated on," but the operation or method of operation is produced by the mechanical means of which the machine is the representative and its only and true interpretation. *Where, therefore, as in the present case the process merely contemplates a series of steps which represent but the consecutive or simultaneous operations of the elements of a machine, and which series of operations are from their very nature so inseparable from the machine as to be incapable of an abstract and independent existence, such steps are simply the expression of the mechanical re-*

lation (relation by virtue of their location) *of the individual elements of the machine—they are the mechanical embodiment of the function or the integral of the individual elementary functions of the mechanism; in effect, the machine itself.*

To cite another case, which from its simplicity will undoubtedly be readily understood, let us suppose that it was old to raise bodies vertically by causing the same to be drawn along an inclined plane; suppose again that some one laid claim to having discovered a mode or method of raising bodies vertically by drawing the same along a helical surface equidistant from a vertically disposed axis or central line. An analysis of that mode or process, discloses that the operation to which the body raised was subjected was a gradual elevation along an infinite series of inclined planes, about a central axis. In other words, we are simply defining the *screw*. The same result could have been accomplished by disposing a *definite* number of inclined planes one above the other, but with a slight angle between their edges so as not to have them continuous. The mode of raising in either case is the same, but the mechanism by which the raising is accomplished is different. With this explananation the scope of a patentable process will be readily comprehended.

A process has been variously defined:

(1.) "A process is a mode of treatment of certain materials to produce a given result; an act or a series of acts performed upon the subject-matter to be transformed and reduced to a different state or thing, and if new and useful, it is patentable." "In the language of the patent law, a process is an art."—(Cochrane *vs.* Deener, C. D. 1877, p. 42; also 4 Otto, 781.)

(2.) A process is "an operation performed by rule, to produce a result by means not solely mechanical."—(Walker on Patents, p. 7.)

(3.) "Where the result or effect is produced by chemical action, by the operation or application of some element or power of nature, or of one substance to another, such modes, methods or operations are called processes."—(Corning *vs.* Burden, 15 Howard, 252.)

Without discussing the comparative merits of the various definitions, each of which was framed subject to the peculiar circumstances governing the learned judges in each particular case, it will be observed that to have a process there must be a series of steps following each other in rational order and productive of some

result that is useful. The organization of the process must be such that its individual elements or steps referred to, shall be capable of representation without making it obligatory on the mind to associate them with the machinery necessary to carry them out. They are not such steps, therefore, which upon integration will define the function of the machine to which these steps belong. They are steps in the abstract. Upon reference, however, to the definition set down by the learned judge in the case of Cochrane *vs.* Deener, it will be observed that the definition is equally applicable to the "process" (function) presented in the treatment of the bloom by the Burden patent. In the latter case, we also have "an act or a series of acts performed upon the subject-matter to be transformed and reduced to a different state or thing." *A priori* we should interpret the definition as applying equally to both function and process. It is, however, saved from misinterpretation by the supplemental statement that, "The process requires certain things to be done with certain substances and in a certain order; but, the tools used in doing this may be of secondary consequence." This qualification of the definition is clearly sufficient to distinguish a process from a mere function of a machine; for it follows that a change of machinery or tools in no wise affects the process, and the latter may be carried out by as many machines as will suggest themselves to those skilled in the respective arts. In the case of function any change in the machine will produce a corresponding effect in the function (except in cases where the *equivalent* of one mechanical element is substituted for that element, which substitution virtually does not represent any change, as an equivalent performs the same function in substantially the same way and mechanically acts in the same manner as the element for which it is substituted). That a change in a machine (or any element thereof) involves a change in function can be readily illustrated in the patent to Burden above referred to. When we contemplate a mode of "preparing of the puddlers' balls as they are delivered from the puddling furnace, ... by causing them to pass between a revolving cylinder and a curved segmental trough adapted thereto," the mind, in order to conceive such a mode or process, must immediately picture for itself a *machine*, the elements of which correspond to "a revolving cylinder and a segmental trough" in close proximity. Without association of the machine there could be no con-

ception of any such process. If instead of the above mode we had a mode of preparing such balls by treating the same between a reversible eccentric cam and a corresponding trough, the mind would correspondingly be obliged to picture a machine whose mode of operation differed from that defined in the Burden patent. This fact not only demonstrates the inseparableness of function from a machine, but also proves that a change in one involves a change in the other. Not so, however, in case of a process. An illustration of this might well be preceded by what the writer conceives to be as comprehensive a definition of a process as any heretofore offered. A process may be defined as *an operation represented by a series of individual operations or steps which are themselves independent of the machine by means of which they are carried out, and are in no wise expressive of the mechanical relations existing between the elements of said machine.* The following claims taken from the specification of letters-patent No. 386,347, July 17, 1888, to Wm. E. Prall, Washington, D. C., for a "Method of supplying steam and hot water for power and heating purposes," will illustrate this point clearly.

(1.) "The herein-described method of supplying high and low pressure steam for power and heating purposes, which consists in supplying superheated water at high pressure, converting a portion thereof into high-pressure steam by allowing it to expand, and by converting a portion of the remainder into low-pressure steam by allowing it to expand, substantially as shown and described.

(2.) "The herein described method of supplying power and heat, which consists in supplying superheated water at high pressure, converting a portion thereof into steam at high pressure, which is supplied for power purposes, by allowing it to expand, converting a portion of the remainder into low-pressure steam, which is used for heating or other purposes, by allowing it to expand, and circulating the water not converted into steam for heating purposes, substantially as shown and described.

(3.) "The herein-described method of supplying high and low-pressure steam for power and heating purposes, which consists in supplying superheated water at high pressure, converting a portion thereof into high-pressure steam by allowing it to expand, superheating the steam thus formed, and converting a portion of the superheated water not formed into steam at the first expansion

into steam at low pressure by allowing it to expand, substantially as shown and described.

(4.) "The herein-described method of supplying power and heat, which consists in supplying superheated water at high pressure, converting a portion thereof into high-pressure steam for power purposes by allowing it to expand, superheating the steam thus formed, converting a portion of the superheated water not formed into steam at the first expansion into low-pressure steam for heating purposes by allowing it to expand, and circulating the remainder for heating purposes, substantially as shown and described.

(5.) "The herein-described method of supplying steam and hot water for power and heating purposes, which consists in supplying superheated water at high pressure, converting a portion thereof into steam for power purposes by allowing it to expand, superheating the steam thus formed, and circulating the water not formed into steam for heating purposes, substantially as shown and described."

It is evident that the various steps of the process as set forth in the claims suggest to the mind no specific relation of mechanical elements, and consequently no particular form of apparatus. Examining the first claim, for example, we may conceive several ways by which "superheated water at high pressure" might be supplied. It might be supplied in metallic casks capable of resisting high pressure, or through pipes connected to a central boiler in which the water was heated. Again, its expansion into high and low-pressure steam could be effected either through the instrumentality of proper pressure regulator valves and chambers, wherein such expansion could take place, or even without the pressure regulators, but controlling the expansion by varying the temperature of the walls of such chambers; *e.g.*, a cold wall would result in low-pressure steam, owing to partial condensation, and a hot wall would tend to the production of high-pressure steam. The claim, however, as drawn suggests neither the one form of apparatus, nor the other. In practice, of course, that form of apparatus is chosen which gives the best results.

Reference was made in the first part of this paper to the analogy existing "between the relation of individual elements of a (mechanical) combination and the successive steps involved in the formation of a process." The analogy has undoubtedly by this

time become sufficiently apparent to enable us to understand an analysis of the latter into genera, sub-genera and species. The possibility of such an analysis will accordingly necessitate a modification or explanation of the statement made in our former paper that "a method or process claim can not be made specific to any generic claim." A process, as heretofore stated, contemplates a series of steps or individual operations productive of some useful result. For any one process, the steps are always taken in one and the same order of succession, and any variation in the order, or reversion of that order constitutes a *different* process; but, we may also produce a different process by reducing the number of the steps (or adding to them) taken *in the same order;* or, by the same reduction in the number of steps, we may produce a sub-process (generically) under the general process. A sub-process necessarily contemplates a complete process as far as it goes, that is, a process productive, at that particular stage of the operations, of some useful result. A good illustration of this point is found in the claims of Prall above cited.

To explain, the first claim covers three distinct steps, viz.: (1) "Supplying superheated water at high pressure," (2) "Converting a portion thereof into high-pressure steam," and (3) "Converting a portion of the remainder into low-pressure steam." The second claim covers the same steps, *in the same order*, but contemplates an additional step, viz.: (4) "Circulating the water not converted into steam." Accordingly, the first claim, though covering a complete process (and, in case the inventor did not care to carry it beyond the scope of the invention as set forth in said claim, we might say covering a distinct and independent process), nevertheless becomes a claim for a sub-process when compared with the process as set forth in claim 2. Claims 3 and 4 have the additional step of "superheating the steam thus formed," *i.e.*, the high-pressure steam. An analysis will show that claim 3 is for a sub-process under claim 4.

We see, then, under the examples of process and sub-process, that one process may be changed to a different one by either the addition of a material step to the series of steps composing it, or by the subtraction of an old step in the series to which it belongs. Of course where such subtraction would result in a remaining series of steps productive of no useful result in the direction of

the process as a final or complete one, such series would become what might be termed an incomplete process.

The statement, therefore, made in our former paper in referring to generic and specific processes, is only true as far as it contemplates covering this particular point. A process, however, becomes *specific* when any step thereof or all of them are qualified in any way, the qualification being produced by some *limitation* of that step. The following claims taken from the specification of patent to James Henderson, No. 280,310, June 26, 1883, for the "Art of Manufacturing Iron and Steel," will serve as examples.

(1.) "The process of manufacturing steel or homogeneous malleable iron from phosphoric mixed metal, consisting of the melting of wrought-iron and cast-iron, either of which is phosphoric, and mixing the two metals together, and maintaining this compound of iron, carbon and phosphorus in a molten condition by additional heat in a furnace with *basic reagents*, free from contact with silicious substances, as a lining to the containing-vessel, to remove carbon and phosphorus, and finally adding a compound of iron, carbon and manganese to give steely qualities to the metal, substantially as specified.

(2.) "The process of manufacturing steel or homogeneous malleable iron from phosphoric mixed metal, consisting of the melting of wrought-iron and cast-iron, either of which is phosphoric, and mixing the two metals together, and maintaining this compound of iron, carbon and phosphorus in a molten condition by additional heat in a furnace with a *fluoride and an oxide*, free from contact with silicious substances, as a lining to the containing-vessel, to remove carbon and phosphorus, and finally adding a compound of iron, carbon and manganese to give steely qualities to the metal, substantially as specified.

(3.) "The process of manufacturing steel or homogeneous malleable iron from phosphoric mixed metal, consisting of the melting of wrought-iron and cast-iron, either of which is phosphoric, and mixing the two metals together, and maintaining this compound of iron, carbon and phosphorus in a molten condition by additional heat in a furnace with *basic reagents*, free from contact with silicious substances, as a lining to the containing-vessel, to remove the carbon and phosphorus, substantially as specified.

(4.) "The process of manufacturing steel or homogeneous malleable iron, consisting of the melting of wrought-iron and cast-

iron, either of which is phosphoric, and mixing the two metals together, and maintaining this compound of iron, carbon and phosphorus in a molten condition by additional heat in a furnace with a *fluoride and an oxide*, free from contact with silicious substances, as a lining to the containing-vessel, to remove the carbon and phosphorus substantially as specified.

(5.) "The process of manufacturing steel or homogeneous malleable iron, consisting of the melting of wrought-iron and cast-iron, either of which is phosphoric, and mixing the two metals together, and maintaining this compound of iron, carbon and phosphorus in a molten condition by additional heat in a calcareous-lined furnace with basic reagents.

(6) "The process of manufacturing steel or homogeneous malleable iron from phosphoric iron, consisting of the melting of wrought-iron and cast-iron, either of which is phosphoric, and mixing the two metals together, and maintaining this compound of iron, carbon and phosphorus in a molten condition by additional heat in a calcareous-lined furnace with a calcareous reagent and oxide of iron."

Claim 2 is specific to claim 1, in that the "basic reagents" of the latter are *limited* to "fluoride and an oxide" in the former; claim 3 is a sub-process under claim 1, involving one step less; claim 4 is a specific sub-process involving one step less and limited to "fluoride and an oxide;" claim 5 is a sub-process and specific, as is also claim 6.

A review of the foregoing will disclose one fact, and that is, that claims for combinations of mechanical elements, or claims for processes, when legitimately presented, in each case define the interrelation among the elements constituting the combination or the steps constituting the process. In the one case the elements are concrete, in the other abstract. This relation necessarily implies co-ordination of function, for, as we have seen in the case of aggregation, that without co-ordination there could be no legitimate functional relation; and, using the same comparison which the writer used on a former occasion, viz.: that to a "compound word whose definition depends upon the *limitation* which one of its component parts puts upon the meaning of the others," a combination claim can be compared, it follows that a claim for a process, by virtue of the relation of its component elements, can likewise be compared. It is evident from the above that each

member of any series of individual operations constituting a process is necessarily *restricted*, *modified* or *limited* by that member (of the same series) with which it is immediately associated. When the number of terms of the series of steps in the process is reduced to *one* the question arises, can a claim for a process containing but one step exist, since there is no other step with which any relation can be established; and this inquiry brings us to the consideration of what is known as claiming a "principle." This question was fully settled in the case of O'Reilly *et al. vs.* Morse *et al.*, 15 Howard, 1853, p. 53.

The claim under consideration was the eighth, of Morse's Reissue Patent, of 1848. It reads as follows: "I do not propose to limit myself to the specific machinery, or parts of machinery, described in the foregoing specifications and claims; the essence of my invention being the use of the motive power of the electric or galvanic current, which I call electro-magnetism, however developed, for making or printing intelligible characters, letters or signs, at any distances, being a new application of that power, of which I claim to be the first inventor or discoverer." The claim is in effect one for the "use of the motive power of the electric or galvanic current," irrespective of the *conditions* to which such current must be subjected to produce the effect of making or printing characters at any distance; irrespective of the method involved to produce the required result; and irrespective of the means or mechanism necessary to produce that result. It is simply a claim for a "principle" or law of nature in its naked, bald and unqualified condition; it is a claim "for a patent for an effect produced by the use of electro-magnetism distinct from the process or machinery necessary to produce it." A claim for a principle should not be sustained, for it is obvious that it would preclude other inventors from devising improvements in the means or mechanism, or processes which contemplate the use of the same principle or power of nature. A principle qualified, however, or limited in any way at once becomes a process and will of course be sustained, although the qualification may not be apparent from the wording of the claim itself. The writer has in mind the first half of the fifth claim of the Bell Telephone Patent, of 1876. It is as follows: "The method of transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other

sounds, substantially as set forth." Now, interpreting this claim from the specification, we find that the method "as herein described" includes both the magneto-method and the variable-resistance method, and "as set forth," viz.: "by the vibration or motion of bodies capable of inductive action; or by the vibration of the conducting wire itself in the neighborhood of such bodies" (magneto-method), or "by alternately increasing and diminishing the resistance of the circuit; or by alternately increasing and diminishing the power of the battery" (variable-resistance method). To be successful, it is evident that the current must be kept closed; the operation of the apparatus depends upon the gradual changes of intensity of a continuous current. The difference, therefore, between the claim under consideration and that of Morse is obvious, as the former "is not for the use of a current of electricity in its natural state as it comes from the battery, but for putting a continuous current in a closed circuit into a *certain, specific* condition, suited to the transmission of vocal or other sounds and using it in that condition for that purpose." This case illustrates how near a claim may be made to approach the extreme limit (viz : a principle) of a true process, and yet by proper interpretation still be a claim for a patentable and legitimate process. One claim is for electricity *broadly*, the other for electricity *qualified* by certain conditions.

The writer has attempted in the present paper, which he regards as a brief one considering the nature of the subject treated, to bring out the distinction between those "patent" elements, by no means clearly understood as to their distinctive nature, and constantly confounded in every-day practice, namely combination, aggregation, function, process and principle. Of these, combination and process are the only legitimate ones entertained in claims under modern patent practice.

I am indebted to Mr. W. A. Megrath, one of the examiners of the Patent Office, for the selection of such decisions as were pertinent to the subject-matter under consideration and for suggestions in the preparation of the paper.

A BRIEF REVIEW OF THE LITERATURE ON ORE-DEPOSITS.

By J. F. KEMP.

(Continued from p. 160.)

THE Geological Survey of Great Britain began, in 1846, the publication of a series of memoirs. The survey was then, as it is now, closely connected with the museum of practical geology in Jermyn Street, London, and in this connection the memoirs often introduce descriptions of ore-deposits and statistics of production. Of especial interest are the four which appeared from 1856–1862, descriptive of the English iron-ore deposits.

The lead veins of the carboniferous limestone of Derbyshire and Cumberland, in central and northern England, have long been well known and worked. In 1861 Mr. William Wallace, a schoolmaster, who had lived for many years in the Alston moor district in Cumberland, and who had made many notes and explorations, published a volume entitled, "Mineral Deposits." It only concerns this one district, but for the painstaking care manifested and for the beauty of its maps, the book is worthy of the highest praise. Nevertheless, the study of ore-deposits requires a man with the instincts of an engineer and the training of a geologist. The quaint aphorisms and simple didactic style of Mr. Wallace, while admirable because so natural, seem, however, ill-suited to his theme. The final conclusions are, that the veins were filled from above (Werner's Descension Theory).

There was brought out at Vienna in 1859 a so-called "Mineralogical Lexicon" of the Austrian Empire, by V. von Zepharovich. For the area treated, a brief but careful description of the occurrence of the various minerals is given, and, incidentally, in speaking of those used as ores, much valuable information is recorded about the local ore-bodies. A second volume, by the same author, appeared in 1873, which brings the first down to the latter date.

In 1861–62 the Wisconsin Survey published Volume I. of its reports. In it (pp. 221 and following) J. D. Whitney describes at length the upper Mississippi lead region, including Iowa, Illinois, and Missouri. Descriptions of these deposits had been previously made by D. D. Owen, 1839 (Senate Documents, 1844); by E.

Daniels, 1854 (Report of Wisconsin State Geologist); by J. G. Percival, 1856 (Report of Wisconsin State Geologist); by J. D. Whitney, 1856 (Metallic Wealth of U. S., p. 403), and in 1858 (Iowa Geol. Report, vol. i., p. 422); but the volume under consideration is the culmination of the others. The author first sets forth the geographical extent and individual characters of the gash veins, proves them to be substantially limited to the Galena limestone, and to have, when productive, a quite uniform strike nearly east and west. He makes it clear that the cavities have originated after the manner of joints, and probably by gentle movements of the strata. The possible modes of deposition are then taken up, and the impossibility of the previously advocated origin by ascension from below convincingly demonstrated. The abundant animal and plant remains of the Galena limestone are then advanced as having furnished, by their decay, the sulphuretted hydrogen necessary to precipitate the galena, blende, and pyrite. The primary metalliferous solution is thought to have been the overlying ocean. The precipitated sulphides were deposited either directly in their present cavities, or else distributed at large through the limestone and afterward segregated in the gash veins. The thesis is worked out in a perfectly clear and convincing way, and is one of the most brilliant efforts in the history of American geology. Additional local details, by J. D. Whitney, were published in the Report of the Geol. Survey of Illinois, vol. i., p. 153, 1866; by James Shaw, *idem.*, vol. ii., p. 40, 1873; by C. A. White, Iowa Geol. Survey, vol. ii., p. 339, 1870; by Moses Strong, Wisconsin Geol. Survey, vol. ii., p. 689, 1877. In the fourth volume of the Wisconsin Survey, published in 1882, p. 367, T. C. Chamberlain takes up the lead deposits again in detail, and after a most exhaustive consideration makes the following modifications of Whitney's theory. A system of Lower Silurian oceanic currents is traced out for the interior region, which may have formed a great eddy in the lead district. Here, at all events, accumulations of marine vegetation took place in the depressions of the bottom which, by their decay, precipitated the galena in a very finely disseminated state throughout the then forming galena limestone. From these disseminations the galena was afterward segregated in the cavities by atmospheric waters, and there precipitated by the sulphurous exhalations of the lower bituminous strata. Professor Chamberlain's discussion is very exhaustive, and it will re-

quire an ingenious geologist to add anything further to the history of the gash veins.

After the publication of v. Cotta's treatise, the further study of ore-deposits did not lapse at Freiberg. A series of monographs was brought out, in the years 1865–67–69, by a commission appointed to further investigate veins (Beiträge zur geogn. Kennt. der Erzegeb.). Four numbers were issued, chiefly concerned with the local ore-bodies and the tin veins of the neighboring districts.

In the year 1869, Johann Grimm, director of the mining academy at Pribram, in Bohemia, published a treatise on the deposit of the useful minerals (Die Lagerstätten der nutzbaren Mineralien). Grimm's point of view is essentially geological. The ore-deposits are consistently treated as forming more or less extended and definite components of the earth's crust, and their origin and relations are discussed with greater reference to scientific considerations than to economic value. In his classification, particular shape or form figures less prominently than in von Cotta's, and less is said of the distribution of ores the world over. Grimm's classification* is as follows, and in some respects is a distinct advance, in that greater emphasis is placed on genetic principles.

Useful minerals occur as:

I. Essential component minerals and inclusions in country rock,
  a. Original with the enclosing rock.
  b. Fragments brought from a distance.
    1. Placers. 2. Ore-bearing boulders, breccia.

II. Deposits individual and distinct from the country rock,
  a. Tabular masses,
    1. Beds. 2. Veins. 3. Sheet-shaped segregations.
  b. Irregular masses,
    1. Interbedded masses. 2. Irregular masses not interbedded. 3. Reticulated veins.

Grimm's treatment of the subject is philosophical, and in many ways admirable. His style is, however, none too clear, and for those less informed than himself, a confessedly obscure subject is made none the less so by his treatment.

Mention was made above (p. 59) of the *American Mining Magazine*. Instead of three volumes, as there stated, nine volumes

* Compare, Monographs, U. S. Geol. Survey, No. vii., Eureka Silver-lead Deposits, p. 118; Monograph No. xii., on Leadville, pp. 368, ff.

were issued under this title. After its lapse, in 1857, a number of journals appeared in New York under various names,* and had careers chiefly marked by their brevity. In 1866, however, the *Engineering and Mining Journal* was begun (with a different name) under the editorship of G. F. Dawson. R. W. Raymond was added in 1867, and in 1869 the journal took its present title. With some changes in the staff it has remained ever since a repository of many valuable contributions on the mineral resources of this country—occupying much the same position here that the *Berg. û. Hütt. Zeitung* does abroad.

In our own country the demoralization occasioned by the civil war checked the development of the surveys, and not until the close of the decade do we find them, both State and National, once more in operation. In this connection it is of moment to consider only the reports of those States which possess important ore-deposits.

The New Jersey Survey brought out its chief volume in 1868. This contains many valuable descriptions of the local ore-bodies, they consisting almost entirely of magnetite lenses and the related franklinite beds. In accordance with the earlier report and views of Dr. Kitchell (1856), they are pronounced to be of metamorphic origin, an opinion that has never been seriously controverted since.

From 1869 to 1873 the Michigan Survey, under Brooks, was in the field studying the iron-deposits of the Upper Peninsula. In 1873 vol. i. was published. Previous to this Hermann Credner, a German geologist, now professor at Leipsic, had spent some time in the same field, and had written two accounts (*Zeitschr. d. d. Geolog. Gesell.*, 1869, vol. xxi., pp. 516; *Berg. û. Hüt. Zeit.* 1871, p. 369.) Brooks's first volume gives a history of the development of the country; a general description of the geological formation of the upper peninsula; a lithological description of the rocks (in part by A. A. Julien), and, finally, the geology of the iron district in detail. In another chapter the magnetic properties are treated at considerable length in their practical applications, and we gather from pages 220, 221 that Maj. Brooks regarded the specular hematite as probably derived from magnetite, and the limonites from the hematite. That, however,

* See Smithsonian Miscellaneous Collections, No. 514, p. 379.

the original source of all was limonite as bog-iron deposits in sedimentary rocks, which were subsequently metamorphosed, no one seems to have questioned for the next twelve years or more (except Mr. M. E. Wadsworth). The survey published a subsequent volume in 1873, in which Dr. A. A. Julien treats the lithology in detail. Towards the close of the decade C. Rominger was appointed chief geologist, and in 1878, 1879 and 1880, he repeated the work in the iron districts, with the fuller opportunities afforded by increased development. Vol. iv. of the survey was published in 1884, giving a detailed description of the local geology, and affording a somewhat simpler classification of the metamorphic series. No particular views on the origin of the ore bodies are advanced. Meantime the Wisconsin Survey, as will be noticed later, had been prosecuting investigations on the Archæan of Wisconsin, and two papers of minor importance had appeared abroad.

The mineral resources of this country and its general geology have been for years a favorite field for travel and investigation by prominent engineers and geologists from Europe, especially German and English. American science owes much to Lyell, von Richthofen, vom Rath, Geikie, Credner, and others, as well as to the two next to be mentioned. Herr Wedding, a German engineer, in 1876, in the *Zeitsch. f. Berg. Hütt. u. Sal. in preus. Staat.*, vol. xxiv., p. 330, published a description of the Michigan iron district, and Professor Hans Hoefer, Austrian Commissioner to the Centennial Exposition, published, on his return in 1878, a very interesting, though somewhat brief, account of the American coal and iron deposits (Die Kohlen- und Eisenerzlagerstätten Nord Amerikas), which gives an excellent short description of this and the other iron regions of the country. About 1880 Mr. M. E. Wadsworth set forth in a thesis in the *Bull. of the Mus. of Comp. Zool.*, of Harvard Univ., vol. vii., No. 1 (Notes on the Geol. of the Iron and Copper Dist. of L. Superior), an eruptive origin for these hematite beds. This explanation had been advanced originally by Foster and Whitney (Geol. of the L. Sup. Dist., Pt. ii., p. 68), and had failed to receive the support of subsequent observers until Mr. Wadsworth's visit, nor has it obtained any converts since. Reviews of the paper may be found in the *Amer. Jour. Sci.*, III. Series, vol. xxii. 1881, pp. 152, 320, 402, *S. of M. Quarterly*, vol. i., p. 7.

In 1882 A. A. Julien advanced an exceedingly ingenious explanation for certain iron deposits of interest in this connection (*Proc. Phila. Acad. Nat. Sci.*, 1882, p. 335). Reasoning on the similar association of minerals to be seen in many beach deposits of magnetite sand and certain magnetite lenses, the author argues as an origin a mechanical concentration like the throw of waves on a sea beach. Granting that the gneisses which enclose our magnetite and specular hematite deposits are metamorphosed sediment, this is by no means an unreasonable explanation of those beds whose mineralogical associates are garnet, olivine and ilmenite.

Reference has been made above to the work of the Wisconsin Survey. This was prosecuted from 1873 to 1882 or thereabouts, when vol. i. of the reports was published. This Survey had to deal with deposits similar in all respects to the Michigan ore-bodies, but in a less folded and obscure condition. Prof. Chamberlain, chief geologist, gives his support (vol. i., pp. 81, 82) to the original bog ore theory, as most satisfactory, as does also C. E. Wright (vol. iii., p. 241), and at that time R. D. Irving did the same (*idem*, p. 613, and again, vol. iii., p. 152). Irving's acquaintance with the Archæan rocks of the Penokee District in northern Wisconsin began in 1873, and for the next thirteen years he prosecuted his studies of them and their continuation across the Michigan line. By carefully tracing these ferriferous beds from the undisturbed areas to those most folded and metamorphosed, together with chemical analyses and the study of thin sections, Prof. Irving reached first the conclusion that they were necessarily formed by some kind of sedimentary deposition, and later that this was by the replacement of some rock originally dolomitic or calcitic by siliceous and ferruginous substances. By further analyses the carbonate beds, regarded as representing these original carbonate rocks, were found to be themselves ferruginous and in at least one place to be traceable from an unaltered condition by the gradual replacement of the rhombohedra with the oxide of iron into regularly bedded hematites. These researches are most completely set forth in the *Amer. Jour. Sci.*, 3d Series, vol. xxxii., p. 255, 1886. In reaching his conclusions Irving was much indebted to the aid of C. R. Van Hise, who has very recently (*Amer. Jour. Sci.*, Jan., 1889, p. 32) added a further extremely valuable contribution to the iron ores of the Penokee-Gogebic series. Van Hise

finds the hematites, with large percentages of manganese, to occur in the troughs formed by the intersection of a compact quartzite with intrusive dikes dipping opposite to it. He traces the iron to a source in the layers of cherty carbonates parallel with the quartzite and lying above it. He conceives it to have been leached out of these by the percolating waters, and to have been carried to the point of deposition in the troughs. Here it has replaced the carbonate rocks which originally filled the apices of the troughs. The thesis is a further, and in no way contradictory, elaboration of the theory advanced by Irving, and is notably in accord with the views of Emmons on the origin of the Leadville deposits. While the latter will be taken up in their place, emphasis may be laid at this point on the importance of this new conception of "replacement," or so-called "metasomatic interchange," as one of the most promising suggestions in explanation of origin.

Having followed up the iron deposit of the northern peninsula to the latest results, we may turn to the copper. In vol. i. of the Michigan reports (1873)* referred to above, Pumpelly takes up the geology of the copper-bearing rocks on Keweenaw Point. Keweenaw Point had already been to some extent treated by the same authors who had previously described the iron district; but Pumpelly worked out an explanation for the origin or method of deposition of the copper which has become classic in the science. Foster and Whitney had previously favored an electro-chemical agency as a probable cause of deposition (Rept. 1850, p. 175). Pumpelly found, however, on studying the mineralogical changes which had taken place in the rocks, that alteration had been very extensive; that it had proceeded through a series of minerals involving at one stage a change in the iron present from a protoxide state to a sesquioxide which would occasion a reducing action, and at this stage the copper was precipitated. The copper itself is thought to have been derived either from the trappean flows or from sulphide masses deposited in the associated sedimentary beds, and to have been brought to its present resting place as carbonate, silicate, and sulphate in solution, there to be reduced to the metallic state. This explanation has been very generally regarded as the true one (see in addition Pumpelly, *Proc. Amer. Academy*, 1878, vol. xiii., p. 233), and has been corrobo-

* The paper was previously published in the Amer. Jour. Sci., 3d Series, vol. ii. 1871, pp. 188–198, 243–258, 347–353.

rated by Irving (*Copper-bearing Rocks*, pp. 61 and 421). It must be considered a perfectly reasonable, if not undeniable, thesis.

In 1875 Mr. Charles Whittlesey reaffirmed the electrical agency (*Proc. Amer. Assoc.*, vol. xxiv., pp. 60–72). Wadsworth's paper has been referred to under iron. Irving's admirable monograph (*Monographs of the U. S. Geol. Survey*, No. 5) treats the geology and petrography of the Keweenawan series, and adds vastly to our knowledge of the extent and character of the system, but in it the ore-deposits occupy a very subordinate place.

(To be continued.)

THE TRANSFORMATION OF ELECTRICITY INTO MECHANICAL ENERGY.*

By W. H. ERB.

On the twenty-fifth day of December, of the year eighteen hundred and thirty, Michael Faraday first demonstrated that electricity could be produced by motion and magnetism.

In order to give a full description of all the results of this discovery up to the present time would fill a library, so we must confine ourselves to a very limited portion, and that, perhaps, the least developed, but certainly not the least interesting, and the one that most concerns us as engineers—the distribution and transportation of energy by means of electricity, and its transmutation into mechanical energy at the place where it is to be used, which may be at a distance from the source of power. This involves, not only the discussion of the principles of the electro-motor, but also the distribution of power in any electrical circuit, and some of the modern applications of electricity as a motive power.

Although Lenz, as early as 1833, perceived the truth that the direction of the induced current is such that its electro-magnetic action tends to oppose the motion which produced it, no one thought for a long time of utilizing that motion in any other way than simply as a laboratory experiment. Indeed, the electro-magnet had been known since 1825, and in 1831 Professor Henry

* Prize Essay of the Engineering Society of the School of Mines.

constructed an instrument on the same principle as the sounder of our telegraph, which was, probably, the first machine for illustrating motion due to magnetism. Since then, many scientists have tried in various ways to utilize such motion, and many and important have been the results therefrom. Among these may be mentioned the sounder of the telegraph, the telephone, and the application of electro-magnets to regulate the motion of the carbons in the arc lamp.

But electro-motors, as machines for transforming electrical into mechanical energy, which shall be used as such, are comparatively of very recent date. Even as short a time ago as 1878, Count du Moucel published a book in which he expressed himself as being very skeptical with regard to the possibility of motors ever being constructed of sufficient size to be used for power—above that required to run a sewing machine.

He says: "If the electro-motor force were, like steam, capable of increasing with the elements which gave it birth, if the dynamic action could act within a certain distance with the same intensity, if the electric fluid did not react by induction, if the current were transmitted in all its strength during a very short period of time, if, finally, the cessation of magnetic action corresponded exactly with the interruption of the current, the problems of electro-motors would have been solved long ago, for never have more ingenious combinations been devised. But it is far from being so; and besides these obstacles, others are added which are part of the nature of bodies themselves: First, their lack of rigidity, which is a natural consequence of their elasticity; secondly, the oxidation of the interrupter by the electric spark, which deteriorates this mechanism and hinders the perfect continuity of the metallic communications; finally, the same stability of effect for a powerful magnet as for a feeble one."

A simple form of motor is one in which the current enters at the brushes, and passes through the collectors of the armature, which is arranged so as to revolve before the poles of a permanent steel magnet. When the current flows in it induces a north pole in one arm of the armature and a south pole in the other. If the north pole in the armature is near the north pole in the magnet, repulsion will take place between them, and the armature will revolve so as to separate them. The same thing will take place with the south pole, and the motion will be equal to the sum

of the two tendencies. At the same time, the south pole of the magnet will have been attracting the branch of the armature which was repelled by the north pole, and *v ce versa.* This motion will continue until the north pole of the armature is directly opposite the south pole of the magnet, where it would tend to remain; except that at this point the collector has turned around so that the brush which rested on one strip of the commutator now rests on the other, and the direction of the current in the armature has changed, so that it now comes in at the back door. This changes the poles, so that the arm which had a north pole now has a south pole, and being opposite to the south pole of the magnet it is repelled. The inertia due to the revolution is sufficient to carry the armature past the dead-point, so that, when repulsion again takes place, it causes motion in the same direction as before, and thus we get continuous rotation.

In a magneto it is evident that the rotation will be in the opposite direction to that which will produce a current in a given direction if the machine were used as a generator, from the converse of Ampere's well-known rule, "That if a man swimming with a current opposite either the north or south pole of a magnet, and looking along the positive direction of the lines of magnetic force, then the conductor will be deflected towards his left." Also, as the polarity of the magnet does not change, if we reverse the current, the rotation of the armature will be in the opposite direction to what it was at first.

If the machine, when used as a generator, were a dynamo, the case would be different. A dynamo is generally constructed to have positive rotation, and cannot be run in the opposite direction without changing the connections. The direction of the current depends on the polarity of the iron in the field magnets, which is not determined until the current has been started, and is determined by the small amount of natural magnetism or by magnetism furnished by a few cells of battery. This polarity being once established is never lost. If a current is sent into a machine in the same direction that it would generate if run as a dynamo (if it is series-wound), the rotation will be reversed as before. But if the current is sent in in the opposite direction, the polarity of the magnets will be reversed at the same time as the direction of the current in the armature, and the rotation of the armature will be in the same direction as at first. Thus we see that in a series-wound

motor the rotation will be in the same direction, whichever way the current traverses it, which will be in the direction opposite to that in which it must be run as a dynamo.

On the shunt-wound machine, when the current arrives at the brushes it divides, and part goes to the armature and part to the field. This makes the current in the field in the opposite direction to what it would be if the machine were run as a dynamo, having the same direction of current in the armature. Therefore the rotation of the armature will be in the same direction as the dynamo would have to be run to produce a current in the same direction in the armature. If the direction of the current is changed, the polarity of the field will be changed, and the rotation will be in the same direction as before.

In running an electro-motor as soon as the armature starts to revolve there is induced in it a counter E. M. F. to that by which it is run, and which tends to stop the motor. This also lessens the load on the generator, and thus lessens the amount of power that need to be put into it. It would, therefore, seem that the greatest efficiency would be secured when the motor would be made to revolve at the same speed as the dynamo; but at this point the load on the dynamo would be nothing, and, consequently, no power would need to be applied. But no work could be done as the two machines would simply be running each other, which might happen if there were no hurtful resistances, and we would then have perpetual motion.

To find the efficiency of a motor: let $c = \frac{e}{r}$ represent the usual quantities of the dynamo current.

Let $C' =$ current when the counter E. M. F. E' has been set up.

Then $C' = \frac{e}{r} - \frac{e'}{r} = \frac{e - e'}{r}$.

Let $W =$ total amount of work done, and $W' =$ work done by motor.

W must equal W' plus waste heat in dynamo and motor.

$$\therefore \quad W = W' + \frac{(e - e')^2}{r}, \quad . \quad . \quad . \quad (1.)$$

$$\text{Also, } W = C' e = e \times \frac{e - e'}{r}, \quad . \quad . \quad (2.)$$

Equating (1.) and (2.).

$$E \times \frac{e - e'}{r} = W' + \frac{(e - e')^2}{r}$$

$$W' = e \times \frac{e - e'}{r} - \frac{(e - e')^2}{r}, \quad . \quad . \quad (3.)$$

Dividing by (2.).

$$\frac{W'}{W} = \frac{\frac{e\,(e - e') - (e - e')^2}{r}}{\frac{e\,(e - e')}{r}} = \frac{e'}{e}$$

That is, the efficiency depends on the ratio of the counter E. M. F. to that of the dymano. We see that as e and e' approach each other in value the efficiency increases, and at the point where they are equal it would be unity, but that is the case of which we have spoken, when the two velocities are equal, supposing the machines to be of equal dimensions. Therefore at the point where the efficiency would be infinite, the work that could be done would be nothing; so we must find the point at which w' is a maximum.

Expanding (3.),

$$W' = \frac{e^2 - e\,e' - e^2 + 2\,e\,e' - e'^2}{r} = \frac{e\,e' - e'^2}{r}$$

Differentiating with respect to e' and taking the first differential coefficient

$$\frac{d\,w'}{d\,e'} = \frac{e - 2\,e'}{r}$$

Placing the second member of this equation equal to 0,

$$\frac{e - 2\,e'}{r} = 0 \quad e = 2\,e', \text{ or } \frac{e'}{e} = \tfrac{1}{2}$$

That is to say, when the efficiency equal to one-half the work done by the motor is a maximum. We thus have the demonstration of Jacobi's law, which is that "The mechanical work done by an electro-motor is at a maximum when it is geared to run at such a speed that the current in the dymano is reduced to one-half what it was when the motor was at rest." This is theoretical, but practically a motor, just like a man or an eye-bar, gets tired and can't work any more. It is, therefore, more economical not to run the

motor up to the limit of its capacity, and it has been ascertained that the system works best when the speed of the motor is nearly two-thirds that of the dynamo.

The load on a motor must necessarily be subjected to sudden and violent changes, and every change in the load affects the counter E. M. F. and thus the E. M. F. of the dynamo, and so greatly displaces the lead on the brushes, which might have the effect to seriously injure or even burn out the dynamo. It is necessary, therefore, to have some sort of a regulator to keep the counter E. M. F. as nearly constant as may be. The most satisfactory way in which this has been accomplished is by the application of the differential principle used in some arc lamps. The field magnets are wound with two coils so arranged that one having comparatively low resistance will be in series with the external circuit, which in this case will be the dynamo circuit The other coil, which will be of comparatively high resistance, will be wound in the opposite direction, and will be in shunt with the external circuit. When the motor is doing its full amount of work it is running at low speed and its counter E. M. F. is not great, but as soon as the load is removed the armature revolves faster, and the E. M. F. is suddenly increased. This going back into the dynamo would suddenly change its E. M. F. and thus the lead of the brushes, so that the commutator might be burnt out, or, at any rate, the wire in the dynamo would be heated; which, if it happened often enough, would ultimately burn out the machine. With this arrangement, when the increased current arrives at the binding post of the motor, instead of traversing the external circuit the excess goes back to the field, and, traversing the coils around the field magnets backward, reduces the magnetism of the field immediately, and thus prevents any great fluctuation in the dynamo circuit. This is a particularly good device as it does not eat up any energy, but simply prevents the consumption of energy by preventing its generation.

There is another matter which has attracted considerable interest, and that is the distribution of the energy in electrical circuit. Of course the method of distribution which is the most desirable is the one in which the greatest efficiency is obtained, and so to find the proper method of arranging the resistances, it is necessary to find an expression for the efficiency of the dynamo.

The dynamo has really two efficiencies: first, the gross or gen-

erative efficiency, which is the ratio between the total electrical energy generated by the machine and the mechanical energy put in at the pulley. Second, the electrical efficiency which is the ratio between the horse-power in the external circuit and the mechanical energy, put in at the pulley as before.

$C\,e$ = 1 volt-ampere = 1 watt; 1 H. P. = 746 watts. Therefore, the work of a current, expressed in horse-power = $\frac{c\,e}{746}$. But $e = c\,r$ so the horse-power of a current = $\frac{c^2\,r}{746}$. The generative efficiency is expressed by the formula

$$F = \frac{\frac{c^2\,r}{746}}{W} \quad \text{or} \quad F = \frac{c^2\,r}{746 \times w}$$

F being the efficiency and w being the work applied at the pulley in horse-power.

In calculating the electrical efficiency two cases must be taken into account: first, the series and then the shunt-wound machine. In the series dynamo the energy of the current divides itself according to the resistances; therefore we may say $f = \frac{r}{a + m + r}$ in which r = external resistance, a = resistance of armature, and m = resistance of field magnets.

It is clear that this fraction increases as "a" and "m" diminish; the r having no effect. The armature and field magnets must be wound so as to use up the least possible energy. This energy is turned into heat, and is not only lost, but deteriorates the machine by heating the insulation to such an extent that it may be burnt, and thus destroy the machine. To accomplish this they must be wound with as large wire as may be consistent with the conditions, which are, that the amount of magnetism in the field depends on the length of wire around it within a certain radius, and the E. M. F. generated in the armature depends on the cross section of the wire with which it is wound. So one extreme must be avoided of having too high resistance, and the other of making the parts too heavy, and putting too much material in the machine for the output of energy.

In the shunt-wound dynamo the conditions are much more com-

plicated. If C represents the current in the armature, then the current in the external circuit is represented by $C\frac{m}{m+r'}$ by the law of branch circuits, which is, "If a current splits, the strength in each branch will be inversely proportional to the resistances." In this discussion letting the letters represent the same quantities as in the last,

The whole resistance, or $R = \frac{m\ r}{m\ +\ r} + a.$

Remembering that the work of any current is equal to $c^2\ r$

$$F\frac{\left(C\ \frac{m}{m+r}\right)^2 r}{C^2\left(\frac{m\ r}{m+r} + a\right)} = \frac{\frac{c^2\ m^2\ r}{m^2\ +\ 2\ m\ r\ +\ r}}{\frac{c^2\ m\ r\ +\ c^2\ a\ m\ +\ c^2 a\ r}{m\ +\ r}} =$$

$$\frac{m^2\ \ r}{(m+r) \times m\ r + a\ (m+r)} = \frac{m^2\ \ r}{a\ (m+r)^2 \times m^2 r + m\ r^2}$$

Inverting this fraction and representing the reciprocal of F by F' and expanding

$$F' = \frac{a\ m^2\ +\ 2\ a\ m\ r\ +\ a\ r^2\ +\ m\ r^2\ +\ m^2\ r}{m^2\ \ r}$$

$$F' = \frac{a}{r} + \frac{2\ a}{m} + \frac{a\ r}{m^2} + \frac{r}{m} + 1.$$

Differentiating with respect to r,

$$d\ F' = -\frac{a\ d\ r}{r^2} + \frac{a\ d\ r}{m^2} + \frac{d\ r}{m}$$

$$\frac{d\ F'}{d\ r} = -\frac{a}{r^2} + \frac{a}{m^2} + \frac{1}{m}, \quad . \quad . \quad . \quad (a.)$$

$$\frac{d^2\ F'}{d\ r^2} = \frac{2\ a}{r^3}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (b.)$$

Placing the second number of $(a.) = 0$,

$$\frac{a}{r^2} = \frac{a}{m^2} + \frac{1}{m}$$

$$a\ m^2 = a\ r^2 + m\ r^2$$

$$r^2 = \frac{a\ \ m^2}{a\ +\ m} \qquad r = \pm\ m\sqrt{\frac{a}{a\ +\ m}}$$

The positive value of r makes the second number of b positive, and the negative value is an impossible one . ·. this value of r corresponds to a minimum value of F', and consequently to a maximum value of F. These expressions show what is the best manner to arrange the resistances in any electrical circuit so as to obtain the greatest return of energy in the current for the amount of energy put into the machine.

Let us consider the relative efficiency of transporting energy by means of electricity, as compared with other methods of transportation. The size of conductors that are to carry an electrical current has been found by Sir William Thompson to be under a peculiar law, namely, "That the conductor must be of such a character that the loss of energy from heating must represent a cost equal to the interest on the capital invested in the conductor." That electricity might be applied to the carrying of energy for long distances may well be shown by the following table, which is made out for 100 horse-power.

	330 ft. $d.$	16,400 ft. $d.$	65,600 ft. $d.$
Electricity, ...	1.80	2.27	4.61
Water Power, ...	2.27	4.03	9.57
Compressed Air, . .	3.17	4.05	6.39
Wire-Rope, ...	1.26	2.88	12.68

For very short distances the tele-dynamic or wire-rope system is probably the best, but for a distance of three miles the efficiency is only about 35 per cent., while for electricity it is 50–60 per cent., up to five miles. In a place where fuel is dear and the only natural source of power is at some distance, as is the case with many of our mines, electricity shows a marked superiority over any other mode of obtaining energy. For with the enormous amount of water power in all our mining districts which is going to waste, because the mines and mining works cannot be placed near enough to this power to utilize it, electricity could be generated which could be carried over the intervening distance with very little loss, and delivered at each separate machine at a less cost than would take to run it by steam. For the different parts of a mining plant are generally scattered over a considerable area of ground, making it necessary to have either more than one steam plant, or to carry their steam or shafting to great distances at the expense of a large amount of power.

The Sprague Electro-Motor Company of this city have undertaken to put in mining plants, every machine of which is to be run by electricity. The excavation to be done by an electric rock-drill of their own invention, and which I believe has not yet been put on the market. The tramming in the mine and on the surface to be done by cars run by electro-motors; hoists and pumps run by electro-motors, and the lighting done by dynamos. All of these things have been tried and run successfully separately, but no plant has yet been put in using all these devices. An electrical tram-car has been successfully used in the mines at Zankerode, and can be used in many mines where steam would be impracticable. At Normanton, Eng., a system of pumps for removing the water run by electro-motors has been in successful operation for some time. Also, several mines in California have adopted electro-motors for running the crushing machinery in their mills, and find it perfectly successful and more economical than the old method which was by steam. That large currents of electricity can be carried for long distances has been proven in Ogden, Utah, where the light plant in the town is run by dynamos ten miles up the cañon, and at less cost than any plant of the same size in the country; the dynamos being run by water power. The only objection the people of Ogden have to their system is the inevitable avalanche which comes down the mountain side, and covers up the machines and turbines, etc., and deprives them of light until they are dug out again.

THE ERUPTION OF KRAKATOA IN 1883.

BY JOHN I. NORTHROP.

I.

EVERYONE has heard or read of the effects of a volcanic eruption, but the cause of the outbreak is more frequently wondered at than understood.

The old Greeks and Romans were content to consider the volcanoes, of which they had any knowledge, as the property of one of their gods or the abiding place of departed spirits; and for a

long time, superstition and fear prevented accurate observation of volcanic action. About a hundred years ago, the illustrious Italian naturalist, Spallanzani, published the results of his study of the volcanoes of his native land, and since that time many workers have entered the field, and our knowledge has steadily increased, until a science has been created and called Vulcanology.

The volcanoes of the world, with two exceptions, have been found to form four irregular lines upon its surface, thus indicating the existence of as many great fissures in the so-called crust of the earth. The exceptions are the volcanoes of the Sandwich Islands and those of the Thian Shan range in the central part of Asia. The lines of volcanic action, as a rule, follow the coasts of the continents, and with the exceptions already noticed, the volcanoes are situated in close proximity to the bodies of water they border. This fact has led vulcanologists to look to the oceans for an explanation of volcanic eruptions.

The line separating fusion from solution is not a sharp one, for it has been shown by adding nitre to a given quantity of water, that when the cold solution becomes saturated, it is only necessary to apply heat to dissolve still more of the salt. By increasing the heat and the addition of nitre, a point may be reached where the mixture can no longer be called a solution, but must be considered a fusion. It has also been proved that rocks containing a certain percentage of water are more fusible than those that contain a smaller proportion, and it is well known that among the minerals, some, as the zeolites, are fusible, while others, containing no water, are practically infusible.

The primary cause of a volcanic outbreak is the heat that is present below the surface of the earth, but it is the slow, very slow, percolation of a small quantity of water through the rock that is supposed to aid in the fusion. During this process, gases are produced that gradually increase in pressure, until at last force enough is generated to overcome the weight above, and an eruption is the result. It has been suggested that a sudden inrush of the sea through a fissure to the molten lava would give rise to an evolution of steam sufficient to cause an eruption, but Professor Judd claims that the effect upon the lava would be to form a crust of chilled material under the water, which would confine the volatile products generated below, and only when the pressure of these

gases became greater than the load above would an outbreak occur.

Most of the material ejected from a volcano falls close to the vent, thus forming a cone that continues to increase in height, until an eruption of exceptional violence entirely removes the upper portion, leaving a ring or crater that Darwin has aptly called the "basal wreck." Within this crater a new cone may be built up, and the former outline of the mountain be restored, to be once more destroyed in its turn.

In the Strait of Sunda, between the islands of Java and Sumatra, are portions of an old crater ring, which, rising above the water, form the islands of Krakatoa, Verlaten, Lang and Polish Hat. One of the grandest lines of volcanic activity on the earth runs through these islands, and is continued eastward through the islands of Bali, Sumbawa, Flores and Timor. There is evidence that a second fissure crosses this main one at nearly right angles, and at the intersection of these two lines Krakatoa is situated. Notwithstanding the important position it occupied, until recently this little island received but a small share of the attention that geologists have given to volcanoes in general. But this is not to be wondered at when it is remembered that Java contains "no fewer than forty-nine volcanic mountains, some of which rise to a height of 12,000 feet above the sea level," and a few are in a state of almost constant activity. In recent geological times, Krakatoa, though now insignificant, rivalled these mountains in size, for if the conclusions that geologists have drawn are correct, the present islands of Krakatoa, Verlaten, Lang and Polish Hat are but the remains of the "basal wreck" of a volcano that rose 10,000 feet above the sea, with a circumference at its base, of twenty-five miles. At some unknown period an eruption took place that removed the central mass of this volcanic mountain, leaving a crater, about four miles in circumference, the highest points of which were but a few hundred feet above the surrounding water.

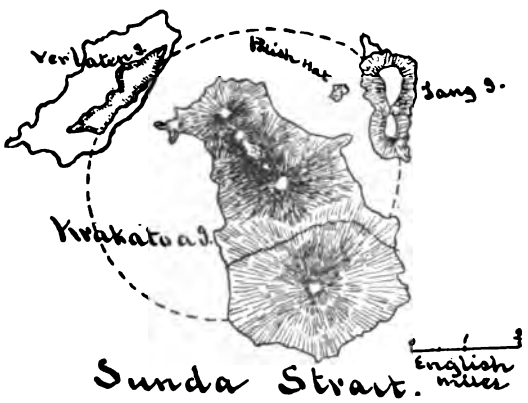
After a series of quiet eruptions that gradually filled up this old crater, a lateral or parasitic outburst seems to have taken place at its southern edge. This activity must have continued for a long time, as it resulted in the formation of a cone about 2600 feet in height. It is this cone "that was called by the natives the peak of Rakata, which, in the old Kawi or Javanese language, signifies a crab. The name, under the Dutch form, Krakatau, the

Portuguese Krakatao, and the English Krakatoa, has been extended to the whole island upon which the striking cinder cone stood."

From the meagre accounts that have been preserved, it seems that in May, 1680, an eruption occurred at some point on the island, and it is probable that Perboewatan was in activity, as fresh lava streams have been seen on its sides by several later authors.

The relative positions of Krakatoa and the adjacent islands are shown in Fig. 1. The broken line indicates the form of the old crater, of which the islands of Verlaten and Lang are portions rising above the strait. The cones within the ring were formed

FIG. 1.



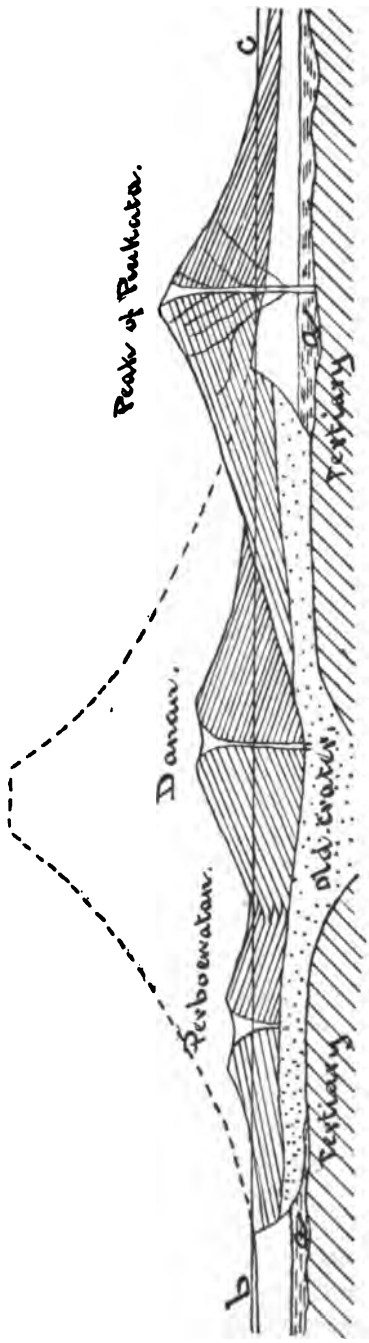
Map of the Islands of the Krakatoa Group before the Eruption of August, 1883. From the "English Krakatoa."

by the quiet eruptions that filled up the crater. The largest cone to the southwest is the Peak of Rakata. During the late eruption almost all of the Island Krakatoa, north of the line drawn through this peak, was removed. The increase of size of Verlaten Island is indicated by the line surrounding it. Lang Island was also slightly added to at the north.

Figure 2 is a section through the length of the Island of Krakatoa and shows its geological position. A thin bed of post-tertiary age (a) rests on the tertiary rocks below, and above it stood the old volcano, whose supposed form is indicated by the broken line. The lateral cone of Rakata is well shown, and also the position of the two small cones—Danan and Perboewatan.

After the eruption of Perboewatan in 1680, for nearly two centuries Krakatoa remained scarcely noticed amid the grander peaks

FIG. 2.



Section through the Length of the Island of Krakatoa, showing its Geological Position. *b c* represents the sea-level. From "Verbeek's Krakatoa."

that surrounded it. But during this time the unseen forces below had been gathering strength, as if to resent this seeming neglect, and the first intimations of what followed were given by earthquakes, of frequent occurrence, that were felt as far distant as North Australia.

On May 20th, 1883, "sounds like the firing of artillery were heard at Batavia and Buitenzorg in Java, nearly 100 English miles from Krakatoa." On the 26th of the same month a party was organized at Batavia and proceeded in a steam launch to the island. It was then seen that the cone of Perboewatan was again in activity. The party succeeded in taking a photograph of the volcano and returned to Batavia. The accounts of the subsequent disturbances are rather indefinite. According to Professor Judd, "the eruption from Perboewatan seems to have had sufficient force to carry the volcanic dust to various points along the shores of Java and Sumatra. After this sudden outburst there was a rapid and marked decline in violence, and then a gradual increase till June 24th, when a second crater had opened in the centre of the island. The eruptive force still increasing, a third crater made its appearance, and innumerable smaller vents were originated all over the surface of the filled-up crater of the great volcano. From this time the activity seemed constantly to increase till its grand culmination on the 27th of August."

On that afternoon and through the succeeding night the forces Krakatoa had so long imprisoned broke loose with a violence unequalled in the records of volcanic activity, and caused the scientific world to give this little island the attention for which it had waited so long.

Shortly after the eruption the Dutch government caused a careful survey of the vicinity to be made, and commissioned Mr. R. D. M. Verbeek, a mining engineer of Batavia, to investigate the cause and effects of the outbreak.

Later, the Royal Society of London took the matter in hand, and on January 17th, 1884, the Council passed the following resolution: "That a committee, to consist of Sir F. Evans, Professor Judd, Mr. Norman Lockyer, Mr. R. H. Scott, General Strachey and Mr. G. J. Symons, with power to add to their number, be appointed to collect the various accounts of the volcanic eruption at Krakatoa, and attendant phenomena, in such form as shall best provide for their preservation and promote their usefulness." The

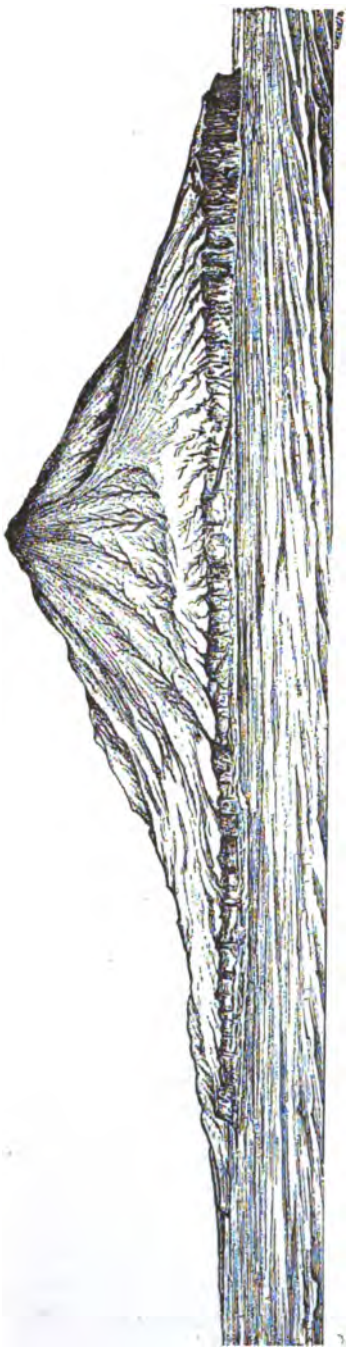


FIG. 3.

Krakatoa after the Eruption of August, 1883, as seen from the Southwest.

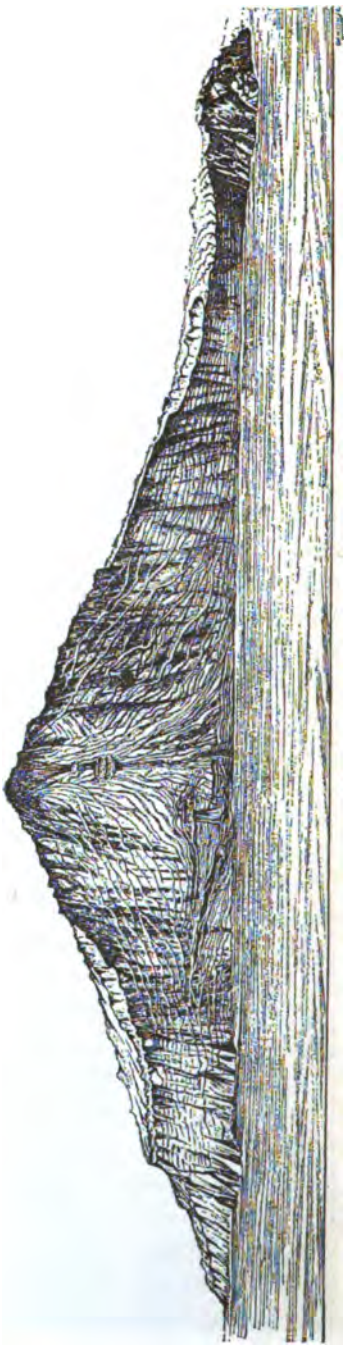


FIG. 4.

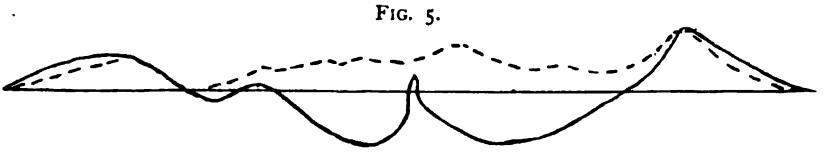
Krakatoa after the Eruption, as seen from the North.

committee inserted a letter in *The Times* and other periodicals, inviting communications relating to the eruption. Later, Dr. Geikie and Professor Bonney were added to the committee. The work of discussing the mass of data collected was commenced about the end of November, 1884. In the spring of 1887 the MS. was completed, and has since been printed in a quarto volume of 494 pages. The results of Mr. Verbeek's investigations were published in Dutch in 1885–86, and afterward translated into French.

It was suggested to me that a description of the eruption might be of interest to the readers of the QUARTERLY. Most of this article is based on the English work, as I have been unable to obtain the first volume of Mr. Verbeek's account.

During the night of August 27th, 1883, the British ship, "Charles Bal," being prevented by the intense darkness from continuing her voyage, beat about within a dozen miles of the east coast of Krakatoa. This vessel and two others in the vicinity escaped destruction. About forty miles from the scene of the eruption were four other vessels, three being at the eastern and one at the western entrance of the strait; while many were at distances varying from 75 to 1000 miles from the volcano. The account of what happened during that eventful night has been compiled from the data furnished by the officers and passengers of these vessels, and the reports collected with so much care by Mr. Verbeek.

FIG. 5.



Outline of the Crater of Krakatoa as it is at the present time.

The broken line indicates the portions blown away during the eruption of August, 1883, and the changes in form of the flanks of the mountains by the fall of ejected materials upon them. From the "English Krakatoa."

The northern portion of the island of Krakatoa was almost entirely removed, and where the land had been three hundred feet high a hollow was formed over a thousand feet below the sea level. The northern part of the Peak of Rakata was blown away, exposing a magnificent section, Figure 4, that has enabled geologists to study the internal structure of the volcano. The island Polish Hat disappeared entirely, and Lang and Verlaten were in-

creased in size; the former slightly, the latter to about three times its former area; while a considerable addition was made to the height of both. The materials thrown from the volcano seem to have covered the sea bottom, within a radius of 10 or 12 miles, to a depth of from 12 to 60 feet. There is some doubt on this subject, however, as the waters surrounding the island had never been carefully sounded, and no accurate survey had been made. There is good reason to believe that the floor of the ocean was raised during the eruption, causing the great sea-waves that will be referred to below.

Along a line about nine miles in length, extending westward from the great crater, a depression seems to have taken place which "was not improbably due to the opening of a fissure on the flanks of the submerged cone." During the eruption two small islands were formed, but both were soon reduced to shoals by the action of the waves. These islands are supposed to have been caused by parasitic cones that had arisen upon the northern flank of Rakata.

The watery vapor thrown into the air reached a height variously estimated from 12½ to 17 and possibly 23 miles. On reaching the limit of its elevation, the mass spread itself and gave rise to the "pine-tree" appearance so often seen during the eruptions of Vesuvius. The surrounding country was enveloped in darkness for nearly twenty-four hours. The electrical phenomena accompanying the explosion were on a grand scale; the lightning darted through the dark clouds "like huge serpents," and "balls of fire" rested on the masts and yard-arms of vessels forty miles away.

Volcanic dust rose to a great height and, floating away, gave rise to the wonderful optical phenomena noted throughout the civilized world. Some of the air-waves generated caused the cracking of walls 100 miles away, and others less violent, though of greater dimensions, travelled nearly four times round the earth. The terrible explosions gave rise to vast sea waves that stranded vessels, and devastated the shores of Sumatra and Java, causing the death of over 36,000 human beings. These explosions formed a notable feature of the eruption, and were probably due to the peculiar situation of the volcano. Owing to the proximity of the ocean, the water, at times, must have rushed in on the molten material. This would at first cause an evolution of steam and then a diminution of activity in the volcano, thus causing a "check,"

only to be followed by an outburst or "rally" of greater violence. In this way the alternations of the "check and rally" are supposed to have caused the unprecedented explosions.

The eruption continued until the 28th or 29th of August, with perhaps a slight outbreak on the 10th of October of the same year. With this last sign of activity the subterranean forces seem to have exhausted their energy and Krakatoa once more relapsed into a period of rest. Such is a general view of the eruption. We will now examine a few points a little more in detail.

Materials Ejected.

The materials ejected from Krakatoa were lava, pumice and volcanic dust. The lava presents two distinct forms, characterized as porphyritic obsidian and porphyritic pitchstone. Both contain the same crystalline elements which constitute about 10 per cent. of the rock; these crystalline elements are felspar, pyroxenes and magnetite scattered irregularly throughout the ground mass. In the obsidian the crystals of felspar have perfectly sharp outlines, while in the pitchstone they are very much corroded, probably by the action of the fluid material which once surrounded them. The most striking difference between these two rocks is shown when they are placed in the flame of a blast-jet. The pitchstone is found to decrepitate and to undergo fusion with the greatest difficulty; the obsidian, on the other hand, fuses with comparative ease, and during the process forms "cauliflower-like masses" that are identical with the pumice thrown from the volcano. The loss suffered by the pitchstone during fusion is *nil*, while the obsidian loses from one to five or six per cent. of its weight. There is no doubt that the pumice ejected in such enormous quantities was formed by the expansion of the volatile gases contained in the obsidian. The condition in which the water and gases existed in the rock is a problem worthy of study.

The pumice contains the same crystals as the obsidian, and also little pieces of a black glass that have been shown to be identical with the pitchstone already referred to. Mr. Verbeek has calculated that the pumice and dust form 95 per cent. of all the materials ejected. Some of the smaller pieces of pumice were thrown to a great height, and were carried by the wind some distance from the scene of eruption; the greater quantity, however, fell close to the

volcano, covering the sea, in places, to such a depth as to effectually hinder the progress of vessels.

As the larger pieces of pumice fell back into the crater, they came in collision with others that were being thrown out, and in this way the pieces were broken, the finer particles forming the volcanic dust. The dust fell in great quantities in the vicinity, and samples have also been collected from many localities, some as far as a thousand miles from the island. Its exceeding fineness is shown by the fact that it penetrated everywhere, no box or watch being sufficiently tight to exclude it. The particles composing the dust have been separated and analyzed, and their optical properties investigated. The appearance and composition of the dust varies considerably; that found in the vicinity is heavier, darker in color, and more basic in composition than that gathered at a greater distance from Krakatoa. This difference is due to the heavy particles of magnetite, pyroxene and felspar it contains.

The quantity of dust thrown into the air is not known, but it was probably much less than that formed at some previous eruptions. The work of trituration, however, continued about three months, and the last paroxysmal explosions of Krakatoa were altogether of exceptional violence and carried the finer particles high into the rarer regions of the atmosphere. From the data supplied by the vessels on which the dust fell, it is found to have covered an area of 1,100,000 square miles. From the depth of the material it is calculated that the quantity of dust was equal in bulk to 3½ cubic miles, while the entire mass of ejected matter equalled about 4½ cubic miles. These figures, however, are estimates and probably only approximate the actual quantities.

Air Waves.

The air waves generated by the eruption were of three kinds: first, those sufficiently rapid to give rise to sound; second, larger waves that caused the breaking of windows and the cracking of walls, a hundred miles away, at Batavia; and third, those of still greater dimensions that travelled several times around the earth.

The sounds caused by the explosions were heard at Ceylon to the northwest; Perth and other stations in Australia to the southeast, and at Manila to the northeast. These places are situated close to a circle drawn from Krakatoa as a centre with a radius of

thirty degrees. To the west the sounds were carried by the trade-winds a much greater distance, and were heard at the island of Rodriguez, nearly 3000 English miles from the scene of eruption. This is interesting not only as being the most remote point at which the reports of the explosions were noticed, but as "the only instance on record of sounds having been heard at anything like so great a distance from the place of their origin." The area over which the sounds were recorded is about one-thirteenth of the earth's surface.

The detonations in the vicinity of the volcano, although very violent, were not as loud as might be inferred from the distance at which they were heard, for the great rain of pumice and the heavy cloud of dust seem to have acted as a curtain through which the sound waves were unable to penetrate. At some places in the immediate neighborhood of the volcano, sounds ceased to be heard after ten o'clock on the morning of August 27th; although it is known that the explosions continued with great intensity after that time.

The great air wave that owed its origin to one of the last paroxysmal outbursts of Krakatoa, was recorded on the barograms at the observatories scattered over the earth. Theoretically, an air wave caused by a sudden explosion would spread in a circle around the earth till it reached a point 90 degrees from its origin; it would then travel onward, contracting as it advanced, till at the antipodes it would come to a focus and thence be reflected back to its starting point, from whence it would once more travel to the antipodes and so on, till it gradually became lost. The barograms that have been collected show that the great wave passed seven times round the earth, four times from Krakatoa to the antipodes, and three times from the antipodes to Krakatoa, the barometers failing to record the fourth return of the wave.

The velocity of the wave varied from 674 to 726 English miles per hour, being very nearly equal to the velocity of sound in air at 50° Fahrenheit, which is 757 miles. There is no direct evidence, however, that the great explosion producing the wave was accompanied by sounds sufficiently loud to be heard at any great distance. The time occupied by the wave passing around the earth was about 36 hours. The wave moving *with* the rotation of the earth travelled with a slightly greater velocity than that going in the opposite direction, viz., about 28 English miles per hour. This

difference is supposed to be due to the winds that blow in a general westerly direction on the path followed by the wave. From the velocity of the wave it has been attempted to deduce the time of the great explosion, and the result agrees very closely with the record made by the gasometer at Batavia; for, when the wave passed over that place, the gasometer leaped from its well, and left a plain, though not very delicate, mark of the time. As thus determined the explosion occurred at 9 hours 58 minutes, local time, on August the 27th.

Sea Waves.

No sea waves were caused by the eruption of Krakatoa during May, but on the morning of August the 27th, several small ones inundated the shores of Sumatra and Java, partially destroying the towns and villages, and causing the death of many of the inhabitants. The number and size of the waves that followed are not known, for the people had fled terror-stricken to the hills, and, surrounded by darkness, were but little fitted to note the changes about them. The most destructive waves followed the great explosions of the volcano some time after 10 o'clock on the morning of August 27th. From the data collected by Mr. Verbeek it has been calculated that the largest of the waves was about 50 feet high before it reached the shore, although the traces it left on the land show that it rose 70 feet above the sea level, and its height has been estimated by some as great as 125 feet. The smaller waves are supposed to have been due to the sudden evolution of steam, caused by the contact of the sea and the molten lava, and by the fall of huge portions of the volcano. The origin of the great wave is an unsettled question. It has been assumed that during the eruption the volcano was raised bodily into the air and fell into the water, thus causing the wave; but this does not seem probable, as the mean period between crest and crest of the waves that followed the great one was two hours, and further, there is no direct evidence supporting this view. It has also been suggested that if an enormous chasm had opened in the floor of the ocean the inward rush of the water would be sufficient to create the wave, —but in this case the fissure would have to be large enough to allow the water to flow into it for an hour with a rapidity sufficient to cause a great decrease in the level of the sea, and the first wave reaching the shore would be a negative one, which it was

not. It is probable that the great wave was caused by an upheaval of the sea bottom, as it is known that the depth of water in the strait was decreased during the eruption, and this may have been due to an upheaval, the fall of ejected material, or to both causes. One of the waves, though not as high as the others, was longer, and probably travelled to Cape Horn, 7520 miles away, and possibly even as far as the English Channel, a distance of 11,040 miles. At such distances the height of the waves becomes very small, and hence their identification is rendered difficult.

The study of the velocity of seismic waves is of recent date. The first observations recorded were made by Prof. W. P. Trowbridge at San Diego, California, in 1855. The waves then noticed were found to have originated near Simoda, Japan, and were due to a submarine earthquake. Since then seismic waves have been found to be of frequent occurrence, although it is seldom that they can be traced to their starting point. This is a matter of some interest, for the speed of the waves bears a constant relation to the depth of the water through which they travel. The velocity of those caused by the eruption of Krakatoa has been carefully calculated, for in this case the time and the place of origin were known. Some doubt is thrown on the result, however, as the same wave could not be positively identified at different places, owing to the rather inclosed position of Krakatoa, and hence the irregular path followed by the undulations; again, some of the tide gauges were situated up rivers and in estuaries where the direct effects of the wave would not be felt. It is quite certain, however, that the velocity of the waves from Krakatoa was less than that demanded by theory, as has also been observed in all previous cases.

Optical Phenomena.

No effect connected with the Krakatoa eruption has been so widely observed and speculated upon as the wonderful appearance the sky presented during the two years that followed the outbreak. Many theories have been offered to explain the phenomena, and while most of these agree that the dust formed in such enormous quantities during the eruption was the primary cause, some contend that the two were in no way connected. It is impossible to give here even a short account of these numerous theories, or the reasons why many have been rejected.

Meagre accounts exist of similar phenomena accompanying previous great eruptions. During the 250 years, from 1500 to 1750 inclusive, there were 65 in which eruptions were recorded, 9 of which were of exceptional magnitude, "and in three of these latter years Denmark was affected by appearances, two of which certainly were of the character of the after-glows, while the third is doubtful."

From 1750 to 1886 the number of "years of eruption" was 90; 25 of the outbreaks being of great magnitude, and of these 16 appear to have been followed by "unusual redness in the sky, or brightness after sunset." Thus it will be seen that in the past like causes have produced like effects, and the lack of information on the subject is probably the fault of observers rather than the want of opportunity for observation. The optical effects of the eruption of Krakatoa, however, were exceptional, and had previous phenomena been so marked and so widely spread over the earth, they would have received more attention than the records imply. The effects of the outburst at Krakatoa were the unusual twilight glows, the blue, green and other appearances of the sun, the sky haze, and the large corona round the sun and moon—all these phenomena were noticed first in the vicinity of Krakatoa.

The dust, after being ejected from the volcano, was carried westward around the earth at the equator, certainly twice, and "perhaps continuously." From this band the particles appear to have spread north and south, and so the phenomena were witnessed throughout the world. The twilight glows travelled westward at the rate of about 72 miles an hour, while the colored suns moved at the rate of about 70 miles. The unusual twilight glows are supposed to have been caused by the *reflection* of the sun's rays from the glassy particles of the powdered pumice that were suspended about 16 miles above the earth. The colored suns were probably due to the *absorption* of certain rays of light by the volcanic dust in the atmosphere. The large corona around the sun was first recorded by Mr. Bishop at Honolulu, on September 5th, 1883, and since that time it has generally been known as "Bishop's ring;" the halo around the moon was noticed in the tropics during the same month. These effects are referred to the lighter particles of dust in the atmosphere, for in April, 1884, when most of the coarser material had settled by gravitation, and the twilight glows began to fade, the corona brightened, then gradually became

fainter, and was last observed in June, 1886, after which the sky resumed its normal appearance.

In conclusion, it may be said that the works on Krakatoa, referred to above, contain many charts, maps, and barograms, and in short form a complete record of all the phenomena caused by the eruption. These works are more valuable than if they contained only the *results* of the reports collected, for, by publishing the *sources* of information, opportunity is given to any one interested in the subject to study *these*, and thereby form his own conclusions. When other eruptions shall have been treated in the same manner more light will be shed on some of the effects now slightly obscured, as the cause of the colors observed in the sky and the origin of the great sea waves. Although eruptions have occurred in the past, exceeding that of Krakatoa both in duration and in the quantity of material ejected, such a complete history of one has never been written till now. This is due in part to the spread of civilization over the earth, and hence the establishment of places of scientific observation. As the number of such observatories will continue to increase, it may be confidently predicted that the phenomena accompanying violent volcanic outbreaks in the future will be more closely observed and more widely recorded.

NOTES ON SOME CHEMICAL QUALITIES OF FOUNDRY IRONS.*

BY C. A. MEISSNER.

In the fall of 1882 a series of experiments were begun in the laboratory of the Brier Hill Iron and Coal Co., at Youngstown, O., with a view to ascertaining what there was about Scotch irons that made them so far superior (?) in quality and selling price to our own domestic makes. That there should be any conditions existent in Scotland, which could not be successfully duplicated here did not stand to reason, and the results of our experiments went far to confirm these opinions. The first definite result ob-

* A preliminary article followed by discussions appeared in several issues of the *Iron Age*, June 7th, 14th, 21st, 28th: July 12th; September 13th.

tained was the fact that manganese, instead of being, as generally held, a detriment to foundry iron, was a positive benefit to it as long as kept in careful control. It is so much more readily oxidized than silicon in the cupola, that it enables the latter element to be retained in greater proportion than were no manganese present, hence the resultant iron is softer and open more from the fact of silicon tending to force the formation of graphite from combined carbon if present in right proportion. Great care must be exercised in keeping the amount of manganese at the right figures, as it has, when too high, a very strong tendency to dangerous sparkling when run out of cupola, as well as to make the castings too hard and brittle.

Silicon is a very important element in foundry irons. Its tendency when not above 2½ per cent. is to cause the carbon to separate out as graphite, giving the casting the desired benefits of graphitic iron. Between 2½ and 3½ per cent. silicon is best adapted for iron carrying a fair proportion of low silicon scrap and close iron, for ordinarily no mixture should run below 1½ per cent. silicon to get good castings.

From 3 to 5 per cent. silicon, as occurs in silvery iron, will carry heavy amounts of scrap. Castings are liable to be brittle, however, if not handled carefully as regards proportion of scrap used.

From 1½ to 2 per cent. silicon is best adapted for machine work, will give strong clean castings if not much scrap is used with it.

Below 1 per cent. silicon seems suited for drills and castings that have to stand great variations in temperature.

Silicon has the effect of making castings fluid, fair, strong, and open grained; also sound, by its tendency to separate the graphite from the total carbon, and consequent slight expansion of the iron on cooling, causing it to fill out thoroughly. Phosphorus, when high, has a tendency to make iron fluid, retain its heat longer, thereby helping to fill out all small spaces in casting. It makes iron brittle, however, when above ¾ per cent. in castings. It is excellent when high to use in a mixture of low-phosphorus irons, up to 1½ per cent. giving good results, but, as said before, the casting should be below ¾ per cent. It has a strong tendency when above 1 per cent. in pig to make the iron less graphitic, preventing the separation of graphite.

Sulphur in open iron seldom bothers the founder, as it is seldom

present to any extent. The conditions causing open iron in the furnace cause low sulphur. A little manganese is an excellent antidote against sulphur in the furnace. Irons above 1 per cent. manganese seldom have any sulphur of any consequence.

Graphite is the all important factor in foundry irons; unless this is present in sufficient amount in the casting, the latter will be liable to be poor. Graphite causes iron to slightly expand on cooling, makes it soft, tough and fluid. Silicon up to 2 per cent. and manganese up to 1 per cent. have the tendency to separate it in casting; phosphorus and sulphur drive it into combination. Some recent experiments on the effect of aluminium on foundry irons by Mr. Keep and others, confirm the statement that graphite is the all-important element. The general effort, therefore, must be towards graphitic iron, and low graphite irons and scrap can only be used in mixtures.

Here, however, let me call attention to the very general error among foundry men regarding *close* iron. Almost every furnaceman has experienced the rejection of iron because it was "close-grained," yet very often this iron was made at the same time when some fine open iron was made. Let me quote some remarks from Mr. S. H. Chauvenet, that are very much to the point.

"When run, the lower bed is almost always close-grain, but shows practically the same analysis as the large grain in the rest of the cast. If the iron runs rapidly and is very fluid the lower bed may have as large grain as any in the cast. If the iron runs rapidly for say, six beds and some obstruction in the tap-hole causes the seventh bed to fill up slowly and sluggishly, this bed may be close-grain, although the eighth bed, if the obstruction is removed, will be open-grain. Neither the graphitic carbon nor the silicon seems to have any influence on the fracture in these cases, since by analysis the graphite and silicon is the same in each. The question naturally arises whether it would not be better to be guided by the analysis than by the fracture. The fracture is a guide, but it is not an infallible guide. Should not the open- and the close-grain iron from the same cast be numbered under the same grade when they have the same analysis?

I have had a great many analyses made for the comparison of fracture with analysis, and unless the condition of furnace—whether the iron ran fast or slow—from what part of pig bed the sample is taken—are known, the fracture is often very misleading. Take the following analyses:

	A	B	C	D	E	F
Silicon	4.315	4.818	4.270	3.328	3.869	3.861
Sulphur	0.008	0.008	0.007	0.033	0.006	0.006
Graphitic carbon	3.010	2.757	2.680	2.243	3.070	3.100
Comb. carbon .	. . .	. . .	. . .	. . .	0.108	0.096

A. Very close-grain iron, dark color, by fracture, gray forge.

B. Open-grain, dark color, by fracture, No. 1.

C. Very close-grain, by fracture, gray forge.

D. Medium-grain, by fracture, No. 2, but much brighter and more open than A, C, or F.

E. Very large, open-grain, dark color, by fracture, No. 1.

F. Very close-grain, by fracture, gray forge.

By comparing analyses A and B, or E and F, it appears that the close-grain iron is in each case the highest in graphitic carbon. Comparing A and E, the graphite is about the same, but the close-grain is highest in silicon.

E and F are from the same cast, F being in the pig bed furthest from furnace run; the iron in above analyses does not seem to be due in all cases to chemical composition, but to mechanical troubles. Sometimes when we have two, three or four grades of iron in the same cast the fracture seems to be unmistakably due to the chemical composition, and was no doubt made under different conditions in the furnace. It is more misleading to send an iron containing 4 per cent. of silicon and 3 per cent. of graphitic carbon, but with a gray forge fracture, to a puddle mill, than it would be to send a large grain with the proper amount of silicon and carbon to the same mill."

In connection with above remarks on graphite, the following may prove of interest.

It is well known that the main effort of a furnace manager must be directed towards making as large a percentage of open iron as possible. Yet as shown in Mr. Chauvenet's quotations, iron from the same cast is often very irregular; part of this is due to natural causes, such as irregular working of the furnace in slow running of the iron and hence frequently beyond the immediate remedy by the manager. A good deal, however, is due to carelessness after casting, and it is to warn against this that I bring out the following remarks and analysis. I will not now touch the question of burdening or running the furnace with a view to getting open iron. It does not belong to the scope of this paper and it is presupposed that the manager has done everything right in this line.

What I refer to as irregular is too rapid cooling and chilling of the iron. I have seen iron that was broken and cooled with water while still almost molten, with the result that the iron was irregular in grain. The separation of graphite is a simple crystallization, and like all crystallizations must have time. The more time before disturbance the larger the crystallization is and *vice versa*. Hence if iron is not given sufficient time to "set" it will certainly be irregular. I have tried this experiment again and again with always the same results. The sow and the junction of sow to pig will, if iron is disturbed too soon, show larger grains than the pig itself, because the former are generally the larger and hence the slower cooling parts. If, however, the iron is covered with coke dust or sand and allowed to lie until fully set, it will be found almost invariably that sow and pig will have the same grains and the cast be generally uniform in grain. This may seem very obvious, yet I have so frequently seen this rule broken on the plea of "no time," that I mention it specially. It will certainly pay the manager to make some arrangement to gain the time and in nine cases out of ten he can do so. The following analyses bear directly on this point.

Pig when broken at plane of contact with sow and in center of pig, center showed spot which plane of contact did not. (Fig. 4.)

Plane of contact with sow, open, uniform.	Center of pig show irregular grain with spot in center.	Spot.
Silicon 2.43	2.23	2.10
Phosphorus 0.740	0.730	0.760
Manganese 1.65	1.60	1.54
Graphite 3.40	3.00	2.50
Carbon 0.22	0.58	0.68
Total C. 3.62	3.58	3.18
Sulphur 0.010	0.012	0.016

	1.	2.	3.	4.
Silicon, ...	2.38	2.20	2.23	2.31
Manganese, . . .	0.58	0.61	0.60	0.78
Phosphorus, . . .	0.250	0.249	0.247	0.275
Graphite, ...	4.00	3.80	3.91	3.25
C. Carbon, . . .	0.10	0.25	0.20	0.70
Total, ...	4.10	4.00	3 95	3.95

Analysis 1.—Fig. 5 broken across *d* show open, uniform structure. Analysis 2, broken across *c* show less open, less uniform.

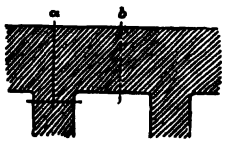


Fig. 2.

Fig. 3.

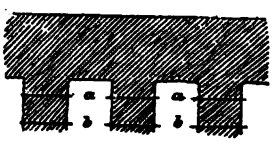


Fig. 4.

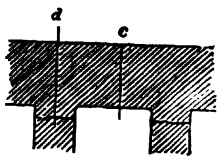


Fig. 5.

Analysis 3, Fig. 4, pig broken at *a* plane of contact, open, uniform. Analysis 4, pig broken at *b*, center of pig, closer, irregular grain.

Fig. 3. Pig with Spot in Center.

	Open part.	Spot.
Silicon,	2.05	2.01
Manganese,	0.79	0.80
Phosphorus,	0.250	0.274
Graphite,	3.10	2.25
Carbon,	0.50	0.88
Total,	3.60	3.13

A few remarks on the qualities of various ores for foundry irons may be of interest.

Hard magnetites, when used alone without admixture of soft ores, do not generally work well. The iron is liable to be hard and very close; open iron is only obtained with heavy fuel ratio. They work well when about one-fourth or one-third of a mixture. Hard hematites are, however, in my experience, preferable in a mixture. Excellent results have been obtained by using one-half soft ores with one-half hard hematites, such as the rich Minnesota ores. To get the right amount of manganese we always preferred such ores as the McComber, Youngstown, etc., running 5 to 7 per cent. manganese, to high manganese ore running 15 per

cent. or over. Such ores are liable to raise the manganese too high in the iron should any irregularity in charging or working occur. The greatest variety of ores is certainly found in the Lake Superior, Gogebic, and Minnesota ranges, where any desired mixture can be made up to suit any analysis. The South, however, seems to have wonderful resources that way, which unfortunately do not seem to have been developed in their chemical capacity to any great extent. The Ohio and Kentucky Blackbands give about the best results for irons to compete directly with the best Scotch. About one-half to two-thirds Blackband (roasted) to one-half or one-third soft rich hematite gives beautiful, open, soft iron at very small fuel ratio.

The Carbonate ores, furthermore, give a very cheap, soft, and open iron, mainly silvery, high silicon, which makes very fine irons to use with a heavy scrap mixture. We have frequently made very cheap irons by using clean carbonates, about one-fourth rich hematites, and about one-eighth mill cinder, and found ready sale for them. Mill cinder should be used sparingly, but when so used has a good effect on the furnace, keeping her moving very free. Blackbands and carbonates should only be accepted on analysis; they run from five to forty-seven per cent. iron, and are so deceptive in appearances as to cause any one to err as to their value, even when well informed on the subject.

It is necessary to figure closely on the loss of manganese in the furnace. This varies between 15 and 20 per cent., according to amount of manganese in mixture. The following figures show this and also other losses:

Manganese in Pig-Iron.

I.	II.	I.	II.
1.00	0.9000	3.00	2.60
1.50	1.30	3.50	2.80
1.80	1.60	4.00	3.00
2.10	1.70	4.50	3.50
2.70	2.20		

I. Theoretical per cent. from ore mixture not counting on loss. II. Actual per cent. found in pig-iron.

As to the losses in the cupola in remelting Professor Ledebur states them very minutely.* Some experiments made at a foundry by myself may be of interest, and are as follows:

* See "Das Roheisen," etc., by A. Ledebur.

Results of Iron from Cupola. Sewing Machine Castings.

	Pig.	Casting.	Pig.	Casting.	Pig.	Casting.
Si. .	2.95	1.67	2.85	2.12	2.90	1.70
P.. .	0.636	0.632	0.640	0.610	0.638	0.632
Mn. .	2.80	1.90	0.80	0.80	1.80	1.60
	Very fluid sparkle; ran without; made considerable slag; percentage of loss quite heavy; castings clean; no shrinkage. Could easily carry two-thirds scrap. Drilled rather hard.		Not quite as fluid; percentage of loss small; castings clean, but not quite as complete. Drilled soft.		This gave the best results. Fluid, small loss; castings clean; no shrinkage; strong. Drilled soft.	

Experiment in Casting Ingot Moulds.

	Mixture of iron used.	Resulting ingot mould.
Silicon, ...	1.17	0.92
Phosphorus, ...	0.180	0.184
Manganese, ...	0.52	0.35
Sulphur, ...	0.036	0.042
Graphite, ...	3.24	3.19
Com. carbon, ...	0.68	0.59

We will now take up the foundry irons proper and their chemical qualifications for the various purposes in view.

I will start with analysis of Scotch irons, samples of which were received by us from various firms using them:

NAME.	Grade.	Silicon.	Phosphorus.	Manganese.	Sulphur.	Graphite.	Com. carbon.
Summerlee	1	2.70	0.545	1.80	0.01	3.09	0.25
"	1	2.47	0.760	2.51	0.015		
"	1	3.44	1.000	1.70	0.015		
" copz.	2	2.70	0 810	2.90	0.02	2.00	0.80
Eglington	1	2.15	0.618	2.80	0.025	3.76	0.21
Coltness	1	2.59	0.840	1.70	0.010	3.75	3.75
Carnbroe copz.	1	1.70	1.100	1 83	0.008	3.50	0 40
Glenarcon	1	3 03	1.200	2.85			
" was said to carry ⅔ scrap.	2	4 00	0.900	3.41	0.010	1.78	0.90

These analyses form the basis of all subsequent ones, and I will begin the list with the American-Scotch irons. They show quite a wide range of analyses, according to the uses to which they are to be put, and to the amount of scrap it is desired to have them carry.

American Scotch Irons.

No. Sample.	Silicon.	Phosphorus.	Manganese.	Sulphur.	No. Grade.	
1	6.00	0.430	1.00	. . .	1	. . . .
2	1.67	1.920	1.90	. . .	. .	casting
3	2.40	1.000	1.70	. . .	2	. . . .
4	1.28	0 690	1.40	. . .	2	. . . .
5*a*	3.50	0.613	2.51	. . .	1	. . . .
5*b*	2.90	0.733	1.40	. . .	. .	casting
6*a*	3.44	1.000	1.70	0.015	1	. . . .
6*b*	3.35	1.300	1.50	0.012	1	. . . .
7	3.68	0 503	2 96	. . .	1	. . . .

DESCRIPTION OF SAMPLES.

No. 1. Well known, Ohio-Scotch iron, almost silvery, but carries two-thirds scrap; made from part black band ore. Very successful brand. The high silicon gives it its scrap-carrying capacity.

No. 2. Brier Hill Scotch castings, made at scale works; castings demanding more fluidity than strength.

No. 3. Formerly a famous Ohio Scotch brand, not now in the market. Made mainly from black band ore.

No. 4. A good Ohio Scotch, very soft and fluid; made from black band ore-mixture.

Nos. 5*a* and 5*b*. Brier Hill Scotch iron and casting; made for stove purposes; 350 pounds of iron used to 150 pounds scrap gave very soft fluid iron; worked well.

No. 6*a*. Shows comparison between Summerlee (Scotch) (6*a*) and Brier Hill Scotch (6*b*). Drillings came from a Cleveland foundry, who found both irons closely alike in physical and working quality.

No. 7. One of the best southern brands, very hard to compete with owing to its general qualities and great regularity of grade and general working.

We will now take up the machine irons:

Sample No.	Silicon.	Phosphorus.	Manganese.	Sulphur.	Graphite.	Com. carbon.	Grade No.
8	2.80	0.492	0.61	0.015	. . .	. . .	1
9	1.30	0.262	0.70	0.030	. . .	. . .	3
10*a*	2.66	0.770	1.20	0.020	2.51	. . .	2
10*b*	3.63	0.411	1.25	0.014	3.05	. . .	1
11	2.10	0.415	0.60	0.050	. . .	. . .	2
12	1.37	0.294	1.51	0.080	2.31	0 78	2
13	3.10	0 124	trace	0 021	. . .	. . .	2
14	2.12	0 610	0.80	. . .	. . .	. . .	. .
15	1.70	0.632	1.60	. . .	. . .	. . .	. .
16*a*	1.45	0.470	1.25	0.009	. . .	. . .	2
16*b*	1.40	0.316	1.37	0.008	. . .	. . .	. .
17	3.26	0.426	0.25	. . .	. . .	. . .	1
18	0.80	0.164	0 90	0.015	. . .	. . .	1

DESCRIPTION OF SAMPLES.

No. 8. A famous Southern brand noted for fine machine castings.

No. 9. Also a Southern brand, a very good machine iron.

No. 10*a* and 10*b*. Formerly one of the best known Ohio brands. Does not shrink; is very fluid and strong. Foundries having used this have reported very favorably on it.

No 11. Iron from Brier Hill Co, made to imitate No. 3; was stronger than No. 3; did not pull castings; was fluid and soft.

No. 12. Copy of a very strong English machine iron.

No. 13. A Pennsylvania iron, very tough and soft. This is partially Bessemer iron, which accounts for strength, while high silicon makes it soft.

No. 14. Castings made from Brier Hill Co.'s machine brand for scale works, very satisfactory, strong, soft and fluid.

No. 15. Castings made from Brier Hill Co.'s one-half machine brand, one-half Scotch brand, for scale works, castings desired to be of fair strength, but very fluid and soft.

No. 16*a*. Brier Hill machine brand made to compete with No. 3.

16*b*. Castings (clothes hooks) from same, said to have worked badly, castings being white and irregular. Analysis proves that some other iron too high in manganese had been used, and probably not well mixed.

No. 17. A Pennsylvania iron, no shrinkage, excellent machine iron, soft and strong.

No. 18. A very good quality Northern charcoal iron.

Next in order will be the silvery irons:

Sample No.	Silicon,	Phosphorus.	Manganese,	Sulphur,	Grade No.
19	2.65	.740	1.70	0.020	3
20*a*	4.00	.521	1.40	. . .	1
20*b*	3.63	.525	1.00	. . .	casting
21	3.80	.880	1.20	. . .	1
22*a*	5 00	1.260	1.50	. . .	2
22*b*	1.75	.500	1.20	. . .	2
23	6.30	1.000	1.62	0.022	1
24*a*	1.80	1.400	2.20	0.015	3
24*b*	0.20	0.090	0.92	0.020	. .
25*a*	6.00	.923	2.34	0.020	1
25*b*	5.65	1.756	1.50	0.022	1
26*a*	2.30	1.360	2.40	0.013	1
26*b*	6.86	1.213	2.34	0.021	1
26*c*	1.30	0.262	0.70	0.033	3
26*d*	2.65	0.907	1.25	0.080	casting
26*e*	1.72	0.975	1.30	0.027	casting
27	3.92	0.658	1.12	. . .	3
28	6.42	1.893	1.65	. . .	1

DESCRIPTION OF SAMPLES.

No 19. Pennsylvania iron, used as softener; will carry one half scrap; made from carbonate ores.

No. 20. Pennsylvania iron, fluid and soft; makes thin castings.

No. 21. New York iron, cheap, fluid, said to carry two-thirds scrap, but doubtful.

No. 22*a*. Used as a softener with good results in mixture of one half with Brier Hill.

No 22*b*. Machine iron (No. 22*b*).

No. 23. Kentucky iron, very soft, competes direct with Scotch along the eastern coast.

No. 24*a*. Silvery iron, which made some excellent much bar, of which 24*b* is analysis.

No. 25*a* and 25*b*. William Jackson Co. iron, famed for softness and scrap-carrying capacity.

No. 26. Drillings of castings sent from large stove company; castings thin, brittle, weak and irregular, but soft where gray. One was nearly white, the other had one white streak between two gray edges. General formation and appearance of castings would indicate that the various irons had not mixed well. Should also judge that the castings, considering their thinness, contained too much manganese, which, together with irregular mixing, caused bad work.

No. 26*a*. Brier Hill, silvery; No. 26*b*. Jackson County, silvery; No. 26*c*. Southern machine iron. Mixture of pig-irons used was 26*a*, 26*b*, 26*c*.

No. 26*d*. White casting.

No. 26*e*. Gray casting with white streak in center.

No. 27. Ohio, silvery, very good for floor plates and other similar work. Carries heavy amounts of scrap.

No. 28. Jackson county iron. Very soft and fluid.

Of mill irons I shall only give two analyses, as they do not rightly belong in this paper:

No. 29.

Si,	0.70
P,	1.10
Mn,	0.30
S,	0.042

No. 30.

Si,	0.87
P,	0.96
Mn,	2.00
S,	0.05

No. 29 was anthracite iron, all magnetite ore; very satisfactory. No. 30 was coke iron, all soft ores; very good.

I will now append a number of analyses of various castings, which may prove of interest:

Sample No.	Silicon.	Phosphorus.	Manganese.	Sulphur.	Graphite.	Com. carbon.
31	2.50	1.400	2.20	. . .	. .	. .
32	0.85	0.351	0.92	0.030	. .	. .
33	1.53	0.327	1 08	0.040	3.10	0.58
34*a*	1.84	0.577	1.04	. . .	. .	. .
34*b*	2.20	0.742	1.10	. . .	. .	. .
34*c*	2.50	1.208	1.16	. . .	. .	. .
35*a*	2.80	0.418	0.54	. . .	. .	. .
35*b*	3.10	1.280	1.14	. . .	. .	. .
35*c*	3.30	0.879	0.80	. . .	. .	. .
35*d*	2.88	0.408	1.10	. . .	. .	. .
35*e*	4.50	0.660	0.78	. . .	. .	. .
36	3.43	1.439	0.90	0.025	. .	. .
37*a*	2.68	0.900	1.30	. . .	. .	. .
37*b*	1.90	0.980	1.20	. . .	. .	. .

No. 31. Sewing machine casting, said to be very fluid and good casting. This is an odd analysis. I should say it would have been too hard and brittle, yet no complaint was made.

No. 32. Very good machine casting, strong, soft, no shrinkage.

No. 33. Drillings from an annealer box that stood the heat very well.

No. 34*a*. Drillings from door hinge, very strong and soft.

No. 34*b*. Drillings from clothes hooks, tough and soft, stood severe hammering.

No. 34*c*. Drillings from window blind hinge, broke off suddenly at light strain. Too high phosphorus.

No. 35*a*. Casting for heavy ladle support, very strong.

Nos. 35*b* and 35*c*. Broke after short usage. Phosphorus too high. Car bumpers.

No. 35*d*. Elbow for steam heater, very tough and strong.

No. 36. Cog-wheels, very good, shows absolutely no shrinkage.

No. 37. Heater top network, requiring fluidity but no strength.

No. 37*a*. Gray part of above.

No. 37*b*. White, honeycombed part of above. Probably bad mixing and got chilled suddenly.

I now give a series of what we called our "standard grades," graded according to analysis, and on which we based all the brands of the Brier Hill Iron and Coal Company:

Brier Hill Scotch Iron Standard Analysis, Grade Nos. 1 and 2.

Silicon, ...	2.00 to 3.00
Phosphorus, ...	0.50 to 0.75
Manganese, ...	2.00 to 2.50

Used successfully for scales, mowing machines, agricultural implements, novelty hardware, sounding boards, stoves, propeller wheels and similar heavy work, chain pumps and similar work re-

quiring no special strength, hardware, carworks, etc. When used for material requiring strength it should be used carefully, with a large amount of scrap. When for material requiring more fluidity than strength it may be used in larger proportions, according to the quantity of scrap or close pig desired to be used with it. Higher manganese may be needed for special purposes, but as that can be added at will in the furnace it need not figure in the standard analysis. The Brier Hill Iron and Coal Company, as the result of these investigations, has succeeded in making a soft foundry iron having all the qualities of the best brands of imported Scotch irons without the use of black band ore, depending entirely upon the ores controlled by the company in the Menominee Range, the Florence, Iron River, and Youngstown:

Brier Hill Silvery Iron—Standard Analysis, Grade No. 1.

Silicon,	3.50 to 5.50
Phosphorus,	1.00 to 1.50
Manganese,	2.00 to 2.25

This has been used successfully for hollow-ware, car-wheels, etc., stoves, car-bumpers and similar work, machines, harvesters, scales, etc., of course with heavy amounts of scrap in all cases.

Should mainly be used where fluidity and no great strength is required, especially for heavy work of above description. When used with scrap or close pig low in phosphorus, castings of considerable strength and great fluidity can be made.

Fairly Heavy Machine Iron—Standard Analysis, Grade No. 1.

Silicon,	1.75 to 2.50
Phosphorus,	0.50 to 0.60
Manganese,	1.20 to 1.40

The best iron for machinery, wagon-boxes, agricultural implements, pump-works, hardware specialties, lathes, stoves, etc., where no large amounts of scrap are to be carried, and where strength, combined with great fluidity and softness, are desired. Should not have much scrap with it, and hence gives more generally reliable results.

Regular Machine Iron—Standard Analysis, Grade Nos. 1 and 2.

Silicon,	1.50 to 2.00
Phosphorus,	0.30 to 0.50
Manganese,	0.80 to 1.00

Used for hardware, lawn-mowers, mower and reaper works, oil-well machinery, drills, fine machinery, stoves, etc. Excellent for all small fine castings requiring fair fluidity, softness, and mainly strength. Cannot be well used alone for large castings, but gives good results on same when used with above-mentioned heavy machine grade. Also when used with the Scotch in right proportion. Will carry but little scrap, and should be used alone for good strong castings. For axles and materials requiring very great strength we made an iron, Grade No. 2, with—

Silicon,	1.50
Phosphorus,	0.200 and less
Manganese,	0.80

This gave excellent results.

A good neutral iron for guns, etc., will run about as follows:

Silicon,	1 00
Phosphorus,	0.25
Sulphur,	0.20
Manganese,	none

It should be open No. 1 iron.

This gives a very tough, elastic metal. More sulphur would make tough, but decrease elasticity.

For fine castings demanding elegance of design, but no strength, phosphorus to 3.00 per cent. is good. Can also stand 1.50 to 2.00 per cent. manganese. For work of a hard, abrasive character manganese can run 2.00 per cent. in casting.

Rough Excrescences and Irregularities in Castings.

The following report made to the general manager may be found of interest: We had received complaints about the castings made from some of our irons, mixed, as it turned out, with several high phosphorus irons, rather below No. 2 in grade. The stove company who complained had evidently not quite understood the character of our irons and used wrong mixtures.

As I understood the complaint, it was that the molten metal would not form perfect joints where the iron united in different parts of the castings, but gave improper castings, showing excrescences and irregularities in mixture, some being gray, some white.

The appearance of the castings sent us which had no irregularity was gray. They were slightly stronger and tougher, and indicated more uniformity. The rough castings, however, were mottled and white, brittle and irregular, though withal soft. Analyses were as follows:

	Silicon.	Phosphorus.	Manganese.	Sulphur.	Carbon.
*No. 38	2.48	0.90	0.90	0.035	3.01
†No. 39	2.47	1.00	0.91	0.042	2.64

These results rather indicate too high phosphorus. No. 39, being mottled and white, and showing higher phosphorus than No. 38, confirms me in the opinion that the phosphorus caused the trouble. Had it been possible to separate the excrescences, we would undoubtedly have found phosphorus in same as high as 1.50 per cent. High phosphorus lowers the separation of graphite and also lowers capacity of iron for carbon, which caused No. 39 to be lower in carbon than No. 38.

To support this theory the following statements of Professor Ledebur are given, who has made a number of extremely interesting and valuable experiments on this subject. See various articles in *Stahl und Eisen*. He gives analyses of a small quantity of white iron, in shape of peas, which had separated out of the upper part of some casting:

	Silicon.	Phosphorus.	Manganese.	Sulphur.	Carbon.
‡No. 40	2.04	0.44	0.43	0.086	3.40
⁂No. 41	1.63	1.98	0.42	0 052	3.06

"As phosphorus does not vary in the process of founding, while Mn, Si, C, and S do, it is plain that the trouble here lay in

* Smooth gray casting.
† Rough, mottled and white casting.
‡ Original casting.
⁂ White, pea-shaped iron.

irregular, high phosphorus. This in case of irons demanding no strength is good; it makes iron fluid, and in general should fill out castings well. But with high phosphorus there is always a tendency to lower carbon, and when the mixture contains many high phosphorus irons, as was the case here also, there is liability of irregular distribution of phosphorus, as the high phosphorus mixtures always vary in phosphorus from cast to cast in the furnace. A sudden preponderance of phosphorus, therefore, would cause just such results."

Now as to castings not forming a good joint and showing cavities. I quote some statements from another authority, Herr Henning:

"In cooling a hard crust forms, and, as contraction takes place more and more, a larger space is inclosed than can be ultimately filled. This gives rise to cavities or sponginess in castings. Heads or reservoirs in large parts of casting counteract this, as hot metal is, through them, continually supplied until all is solidified."

Slow cooling diminishes this contracting, as it favors separation of carbon in graphitic form, in which it expands, thus completely filling out the mould. This explains why a high carbon iron from a hot cupola gives best results. High silicon has the same effect.

Liquid iron very rich in manganese absorbs gases readily, which are set free, on solidifying, in the shape of bubbles. A frequent cause of porosity is contact of foreign bodies, giving rise to gas formation at the moment of solidification and thus causing bubbles. Also, when metal is not very hot, but high in phosphorus, it tends to keep carbon in combination, crust forms rapidly, and iron, on meeting, will not form a perfect joint. (This was probably the case in the castings above referred to.)

It should be kept in mind that for thin, small castings high phosphorus is not desirable, as its tendency to keep carbon in combination is intensified by the rapid cooling of such castings. Fine castings need good, soft iron—not necessarily strong, but fluid and soft. Ordinarily, silicon should be about 2.00, phosphorus not above 0.600, and manganese not above 1 per cent. Therefore, a high phosphorus, high manganese iron which would be cold short should be mixed with red-short or neutral irons. It seems to me that one cause of trouble in this case lay in mixing up the two grades of our Company's iron that was sent to this foundry. One was an open-grade company's Scotch; the other

was Company's machine iron. The former demanded neutral irons and scrap; the latter demanded such irons as Jackson County Silvery, etc., to do good work. As it seemed to me, just the reverse conditions were given.

Take it all in all, therefore, the differences between Scotch and American irons are not by any means as great as has been generally assumed. The one main difference has been heretofore that the Scotch furnaceman had one general mixture which he knew was good and which he clung to, while the American furnaceman has too many different kinds of ores to choose from, and is very liable to choose according to price. This is well enough if he will at the same time keep in view the chemical qualifications of the ore as he can readily do, but if he does not he is bound to deliver an irregular iron, while the Scotchman delivers a regular grade, hence the founder can better afford to pay $2 or $3 per ton more and know what his results will be, rather than pay a less price and risk a failure. There is, however, no need for any risk, if the furnaceman will only keep close track of all shipments to his different customers, supplying each with the general grade, both physical and chemical, which suited him on the first sales. The German Government in 1877 had the same trouble between its own irons and English irons, and, going into a very exhaustive series of experiments, succeeded in proving its own equality with the foreign makers, and holding the position thus obtained. The same is, or ought to be, true in the United States, whose resources are certainly larger and better than those of Germany.

THE MANUFACTURE OF CHEMICAL FIBRE.

BY E. A. CONGDON, PH.B.

I. TREATMENT OF THE WOOD (COOKING AND BLEACHING), AND WASHING OF THE PULP.

POPLAR, pine, spruce and occasionally birch are used in the manufacture of chemical fibre. Pine and spruce give a longer and tougher fibre than poplar and birch, but are somewhat harder to

treat, requiring more soda and bleach. Special reference is here had to the treatment of poplar.

Sticks of poplar (cord wood) peeled free from bark and cleaned from any incrusting matter and dirt, are reduced to chips by a machine of special construction having a heavy iron revolving disk set with two knives, and are then blown by means of a Sturtevant blower into large store chambers after being run over a set of screens having 1¼ inch for the coarse and 1⅛-inch mesh for the fine screens, from whence they are introduced into the digesters.

The digester is simply a large upright boiler, dimensions 7 feet x 27 feet, with a man-hole at the top for the entrance of the chips and liquor, and a blow-valve at the bottom, for the egress of the cooked wood. A steam pipe enters at the bottom below a perforated diaphragm and keeps the liquor in perfect circulation while cooking the wood, by means of a device known as the *circulator*, which is simply a steam ejector of special construction.

An average of 4.33 cords of wood are used to the digester, with an average yield of 4140 pounds of finished fibre per digester; 3400 gallons of 11° "Baumé" caustic soda liquor are introduced into the digesters loaded with chips, the man-head placed in position, and steam turned on.

The filling of the digester occupies thirty to forty-five minutes. Steam is introduced until the gauge shows 110 pounds pressure. To attain this pressure takes about three hours.

The digester is kept at this pressure for seven hours, which is then reduced by allowing the steam to escape into a large iron tank that acts as a separating chamber for the spent liquor that it carries. The steam enters at one end and passes out from the other through a large pipe, the liquor remaining in the tank. The steam is allowed to escape until the gauge reads 45 pounds, at which pressure the digester is blown.

The blow-cap being removed, the blow-valve is raised and the contents of the digester are discharged into a pan of iron, covered with a suitable hood. The contents strike against a dash-plate placed midway in the pan, which thoroughly separates the fibres of the wood.

It takes nine to ten hours to free these pans from alkali, when they are sent over to washing tanks with perforated metal bottoms, where they receive their final washing preparatory to bleaching.

Résumé.

Digester loaded,	30 to 45 minutes.
Hours to pressure,	2¾ to 3 hours.
Hours at pressure (110 pounds),	7 hours.
From pressure to 45 pounds,	45 minutes.
Total, 11 to 11½ hours.	

Washing of the Pulp.—The three digesters have each a pan into which their contents may be discharged. There are four iron tanks used for holding the liquors of various strengths obtained in cleaning the pulp, each holding liquors successively weaker, and a fifth which has been described as the separating tank.

After the digester has been blown, the pulp is levelled down with a shovel and the liquor from the separating tank is allowed to flow into it. The contents of the next strongest pan are then pumped upon it, while at the same time the strongest store tank is flowing into this pan. This flowing from the tank to this pan, pumping from here to the pan just blown, and from there to the evaporators, is kept up until the liquor is not weaker than 6° B., hot (130° F.). The second pan mentioned is now down to 4° hot, and the process of "pumping back" is commenced. The two weakest tanks are put upon this pan and pumped out of the bottom of it into the two tanks in which the strongest liquors are kept. The two weak tanks have been filled in the process of completing the cleaning of the third pan (the weakest) on which water was pumped until the last weak tank tested only ½° B. This pan, now cleaned, is hosed and pumped over to the washing tanks. A fresh blow is now made in this pan, and the same treatment followed out as with the first pan.

Let us illustrate the above system by a practical example:

Pan A, just blown.
" B, partly cleaned.
" C, almost cleaned.

Tank 1, 3½° B. hot.
" 2, 2° "
" 3, 1° "
" 4, ½° "

Separating tank, strong.

A is levelled down. Contents of separating tank allowed to flow upon it. B is pumped on to A, at the same time liquor from the

two strong store tanks is put on it (B) and this continued to be sent from A to the evaporator until it is no weaker than 4° hot; the process of "pumping back" is then commenced. The two weakest are in succession allowed to flow on to it, and the liquor pumped from the bottom of B into the two strong tanks, filling No. 1, the stronger, before No. 2. The weakest are filled in the process of completing the cleaning of C on which water is pumped until the last tank from it tests only ½° B. C is now hosed and pumped over to the washing tanks. A fresh digester is blown in C, and the process repeated as with A.

A modification of the above system consists in having an extra pan into which the liquor from the last pan blown (after sending to the evaporators until down to 6° hot and bringing down to 4° hot by the stored liquor) is pumped. As soon as the strength is down to 4° the pumping is stopped. The liquor from this pan is put on the next pan blown, after the liquor from the separating tank has been put upon it, thus effecting an economy in time.

The pulp after being partially cleaned in the pans still contains quite an appreciable amount of soda. It is hosed over to the washing tanks, and receives a final washing with hot water. When the pulp is thoroughly free from alkali, and the water flowing from under the tanks is colorless, the contents are hosed down by hot water into the bleaching tanks. The superfluous water is removed by revolving washers, and about one thousand gallons of a solution of chloride of lime of a strength of 4° B. are then introduced and the contents agitated and circulated.

In about six or seven hours the bleaching is accomplished and the pulp is pumped into draining tanks where it is allowed to drain down hard, the spent bleach flowing away. The stock is then hosed and pumped into a washing tank where it reaches the proper consistency for the machine. From here it is pumped into the stuff chest, whence it goes over a set of screens and on to the machine from which the finished fibre is run off on spindles. The rolls are made of a convenient size to handle, averaging something over one hundred pounds each. The fibre is dried on the machine by passing over a series of hot iron drums that are supplied with live steam. The finished product obtained is a heavy white sheet somewhat resembling blotting paper.

Time Occupied During the Process (Average).

Wood chipped and blown into store chambers,	2 hours.
Digester filled with chips and liquor introduced,	¾ hour.
Chips remain in digester,	10¼ hours.
Chips blown and remain in pans during the system of washing,	7 hours.
Stock hosed to washing tanks and freed from all trace of alkali,	3 hours.
Stock bleached,	7 hours.
Stock drained, run over machine and finished product obtained,	15 hours.

Total, 45 hours.

II. Recovery System and Method of Leaching.

The spent liquors are delivered to the Yaryan evaporator from the pans at a density of 6° to 7° hot, 130° F. (equivalent to 7.1° to 9.1° at 60° F.). They are here concentrated to 34° to 42° hot, 140° F. (equivalent to 36.4° to 44.4° at 60° F.).

At this density they are fed into furnaces of the reverberatory type where they are burnt to a cherry-red and the ash raked out. This ash averages 50 per cent. soda. It is weighed in iron barrows on suitable scales and is wheeled into the leaching room for lixiviation.

System of Leaching.—Iron tanks are used with suitable piping that allows pumping from one tank to another and also to pump from any one of them up to the causticising tanks in the alkali room. There is also a water line by which water may be pumped into any of the tanks, and there is a spout used in washing the black ash sludge away. The leaching tanks have false bottoms of 2 x 2 stuff, placed crosswise, over which is a layer of gravel on which lies a layer of straw, by which the liquor is filtered The gravel is renewed every few days, and the straw with every fresh charge.

Method of Procedure.—When one of the tanks is filled with black ash, it is "wet down" with the stored liquor (the strongest of the stored weak liquors), and also with the strongest weak liquors from the tanks, and with weak liquors obtained from these tanks by pumping water upon them and keeping them full. This is all pumped up to the causticising tank until the strength is reduced to 2° or 1½° B.

The remaining liquor is then drained into a tank known as the "clear liquor tank" owing to there being no black ash in it. The

liquor from the next weakest pan is then pumped upon the pan containing the black ash, and the next weakest liquor pumped upon this. The weaker pans are then in succession pumped upon the stronger, and water pumped upon these, and thus a very perfect washing is obtained. The sludge left behind is nothing but charcoal with a slight trace of sodic carbonate.

Let us illustrate the above system by a practical example. The tanks stand as follows:

No. 1. Clear liquor, 1° to 2° B. (Strongest.)

No. 2. Black ash sludge. Weaker than No. 3.

No. 3. Black ash after sending up to causticising tank. (Strongest sludge.)

No. 4. Fresh black ash.

No. 5. Weaker than No. 2. (Sludge only.)

No. 6. Weaker than No. 5. (Sludge and weakest liquor.)

Method of Procedure.—Liquor from No. 3 drained into No. 1. (Now full.)

No. 6 pumped on to No. 2. (No. 6 sludge thrown away.)

Liquor from No. 2 drained upon No. 3.

Water put on No. 5. No. 5 pumped upon No. 2. (No. 5 sludge thrown away.

Treatment of the Tank of Fresh Black Ash.—No. 4 full of black ash is wet down with Nos. 1, 2 and 3, and pumped up to the causticising tank.

Water is pumped on to Nos. 2 and 3, and these drained upon No. 4, the liquor still being pumped up from No. 4, while the water is being pumped upon Nos. 2 and 3 which are kept full.

This is continued until the liquor tests only 2° to 1° B.

No. 4 is now drained into No. 1.

No. 3 pumped upon No. 4, and this drained into No. 1. (Now full.)

No. 3 pumped upon No. 3.

Water pumped upon No. 2. (No. 2 the next to throw away.)

No. 5 is by this time full of fresh black ash, and the same process is carried out as with No. 4.

III. Alkali Department.

Preparation of the Soda and Bleach Liquors—Treatment of the Sludges.—The leached sodic carbonate from the black ash is pumped up into the alkali room, where it is causticised with lime,

a proper amount of fresh soda being added to make a sufficient bulk of liquor of the strength desired.

The alkali-room contains five causticising tanks 12′ x 10′, having a capacity of eight thousand four hundred gallons, or seventy gallons to the inch. There is a large store-tank of riveted iron for the caustic liquors 10′ x 8′ x 16′, with a partition of riveted iron dividing it into two equal-sized compartments. In the same room is the bleach system, consisting of two dissolving-tanks 8′ x 8′, a store-tank for weak bleach liquors 10′ x 5′, and another for 4° bleach, the strength used for bleaching the pulp. The five causticising tanks are cylindrical in shape, and are of iron riveted. They have iron covers with openings, through which the lime may be thrown in and the swing-valve operated. The construction of the bleach dissolvers is precisely the same as that of the causticising tanks. Agitators are placed in both, operated by a cog-wheel, whereby the contents may be thoroughly stirred. The bleach store-tank is of brick, cemented, and is boarded over to exclude the light, which has a decomposing effect on the chloride of lime solutions.

Suitable lines of piping allow pumping from one causticising tank to another, and to the store-tank (by means of swing-valves). The liquor may be mixed by taking it out at the bottom and pumping it in again at the top, and may also be pumped from one compartment into the other.

The liquors, when mixed and of the proper strength and causticity, are pumped from the store-tank up into the digester, in which the cooking process of the wood takes place.

There is a similar arrangement of piping in the bleach system. There is also a water-line, by means of which water may be pumped into any of the tanks in the alkali-room.

Method of Causticising.—The leached sodic carbonate liquor and added fresh soda ash are brought to a boil with lump-lime by means of steam introduced into the tank. The boiling is continued ten to twenty minutes, when a portion of the liquid is removed and allowed to settle. If at all turbid it is filtered, and the clear liquor tested in a test-tube with dilute sulphuric acid, 20° B. If very few bubbles of gas escape on adding the acid the liquor is caustic, but if there is a considerable effervescence the presence of sodic carbonate is indicated, and more lime must be added and the boiling repeated. Tests are made in this way by the workmen until the liquor is thoroughly caustic. The causticity of the

liquor will average on analysis over 91 per cent. The average number of pounds of lime used to causticise one hundred pounds of 48 per cent. soda is fifty-two.

Chemical Reaction Involved.—The reaction which takes place in the process of causticising is expressed by the following equation:

$$Na_2CO_3 + CaO + H_2O = 2NaOH + CaCO_3.$$

According to this formula 47 pounds of lime (90 per cent.) are required to render caustic 100 pounds of soda (48 per cent.). Hence 52 is 5 per cent. excess on the figure obtained theoretically, which is not a large excess. Ninety-one per cent. average causticity is fair, for 95 per cent. is the highest practically obtained.

The caustic liquor thus obtained is 12½° to 13½° B. (60° F.), The agitator, which has been in operation during the process of causticising, is stopped and the tank allowed to settle. The heavy insoluble carbonate of lime produced by the reaction settles to the bottom, leaving the clear caustic soda liquor above it. This process of settling occupies about four hours, sometimes longer.

The caustic soda liquor is then pumped off as completely as possible, and mixed with the strongest weak liquor in proper proportion to make the resulting liquor of 11° B. (60° F.), which is the strength used for cooking the wood.

Treatment of the Lime Sludges and System of Washing.—After the strong caustic liquor is pumped off and mixed with the "strong weak" to make the 11° liquor, any left over (after filling the square store-tank with this 11° liquor) is pumped into the fifth tank kept for clear liquor, no causticising being done in it. Any of the "strong weak" left over is also pumped in here. A second boil is made in the tank from which the 13½° liquor has been drawn as completely as possible, using leached sodic carbonate only, and effecting an economy in lime, owing to the excess used in the first place. This is settled and tested as in the first boil. After the liquor is all pumped off and mixed with the "strong weak" stored in the fifth tank, a weak liquor of about 2° is pumped upon the strong sludge, the whole agitated and boiled for a few minutes. The tank is again settled, and after this "strong weak" is pumped off the next weaker is put on, after this a weaker one, then water, and sometimes a second and third treatment with water. These successive weak liquors are all used in washing other tanks in the same way that this was washed. Finally, the lime mud is agitated

with water, and flows off through a gate and is thrown away. Let us illustrate this system by a practical example:

Tank No. 1,	13½° B.
Tank No. 2,	6° B.
Tank No. 3,	2° B.
Tank No. 4,	1 to ¾° B.
Tank No. 5,	Empty.

The 13½° liquor from No. 1 is drawn off and mixed with 6° liquor from No. 2 in the square store-tank to fill it with 11° liquor. Any 13½° and 6° liquors now left are pumped into No. 5; No. 4 is pumped upon No. 2; water put on No. 4; second boil now made in No. 1; draw off and make up 11° liquor from No. 5. No. 2 pumped upon No. 1; No. 3 upon No. 2; No. 4 upon No. 3; No. 1 upon No. 5; No. 4 agitated with water and dumped.

A fresh boil is made in No. 4, and process repeated as above. Slight modifications of this system are sometimes necessary. Occasionally, when the leached carbonate liquor goes down to 2°, it is stopped, and weak liquors from one of the causticising tanks used, thus enabling this tank to receive another washing.

Bleach System.—The contents of two casks of the bleaching-powder, about two thousand pounds, are dumped into a dissolver and thoroughly agitated with water. The resulting liquor is a strong bleach of 8° to 10° B.

The dregs are allowed to settle, and this is pumped off into the store-tank, where it is mixed with weak bleach to bring it down to 4°, the strength with which the pulp is bleached.

The weak-bleach liquor in the second dissolver is pumped upon the dregs in the first to make it 4°, water put upon the second, and after this has also been pumped on to the first, one or two more washings with water are given, the resulting liquors being stored in the weak-liquor tank.

The dregs from the chloride of lime are in this way washed so clean that they contain only a trace of chlorine, an amount too small to be of practical importance.

General Résumé.

The wood is delivered to the mill in sticks of cord wood. Poplar is generally used; bass, birch, and pine are often used. Poplar is the easiest wood to cook; bass and birch are also easy to cook,

but require more bleach. Pine and spruce are much more difficult to cook and to bleach, but give a stronger and longer fibre.

The wood is reduced to chips. The digesters loaded with chips and cooked with 11° caustic-soda liquor for seven hours at a steam pressure of one hundred and ten pounds. Average yield, a little less than one thousand pounds to the cord. The digester is blown at 45 pounds pressure into iron pans protected with hoods; the pulp partially freed from alkali in these pans by a *washing system* using weak liquors obtained by previous treatment. When the last weak liquor sent to the store-tank, tests only ½° B., the stock is pumped over to the washing-tanks, where it receives its final washing; when perfectly free from alkali it is hosed down into the bleaching-tanks, where it is bleached white. The stock is then pumped into the draining-tanks, and *the spent bleach* allowed to drain off. The pulp is reduced to a proper consistency in a washing-tank, and pumped into the stuff-chest. From here it passes over a set of screens to remove shives, and passes on to the machine, where it is run into sheets, dried, and run off on a spindle, and collected in rolls ready for shipment.

The foregoing account of the manufacture of chemical fibre is a brief description of the process as carried out in a mill with which the writer was recently connected.

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*ELECTRICAL ENGINEERING AT COLUMBIA COLLEGE.

PROBABLY few announcements have ever been received with more pleasure by the electricians of New York and its vicinity than that of the past week relative to the intention to establish a course in electrical engineering at Columbia College. In fact, the step is one that will win the cordial praise of the profession in all parts of the country, and we may as well confess for ourselves at once that we hail with keen delight this recognition by one of the

* It is personally known to the editors that this editorial in the *Electrical World* of January 19, 1889, did not emanate in the slightest degree from the School of Mines, and it will gain additional interest in the opinion of the alumni from the fact that those entirely disconnected with Columbia have so earnestly and happily expressed the motives and aims of the promoters of the course.

most prominent and influential American seats of learning of the claims of electricity for support and encouragement.

It is gathered from the statements in the daily press, confirmed by special inquiry on the subject, that the intention of the trustees and faculty of the College is to found a post-graduate course, of one, two or three years, by means of which, under proper instructorship, the young men who entertain the hope of making the practice of electrical engineering their life career, can build on the broad foundation of theory the more special and expert acquaintance with the novel problems in electricity that have already ranged it abreast of the older departments of the arts and sciences, and have demanded for their solution the efforts and experience of a new class of engineers.

It may be taken for granted that the authorities of Columbia in making this move, which will redound so much to her credit and glory, have not acted with precipitancy, and yet if the new departure has been in contemplation for any length of time, we must say that the publication of their purpose is peculiarly opportune. Unless we greatly mistake the tendencies and evidences of the day, there is everywhere not only a hearty appreciation of the benefits that applied electricity can confer on modern society, but an intense yearning to know more accurately and precisely the limitations of the field, whether as a science to be investigated or as an art to be utilized. Even in cultured and well-informed circles one often stands aghast at the wild views expressed by those who, as leaders of public opinion, should know better, while through the mass of the population the ignorance that yet prevails is not far short of utter darkness. It is to our schools and colleges that we must turn for a large part of the educational work that is to change this condition of affairs, and certainly the attempt that Columbia is about to make is of the kind that is most likely to be productive of good results. The preparation on the theoretical side and that which allies electrical engineering to the older standard professions, is such as will naturally fall within the undergraduate course, and then as the student with a ready and ripening mind takes up his post-graduate curriculum he can at once reduce to concrete form all that hitherto lacked definiteness and direction in his work, at the same time being given opportunities to develop into a proficient and expert in the branches that most enlist his enthusiasm and affection.

We have spoken of the need of such men to correct public ideas as to electricity, and to prevent the growth and spread of popular fallacies on the subject. This will, indeed, be a notable part of their mission. Although the art has been greatly helped by the general superstition that electricity can do anything and everything and is exempt from the rule that for power obtained power must be given, its healthful fruitions have frequently been checked by the rank upspringing of countless swindles in the same fertile soil. There is a call for well-educated men, alert of brain and hand, whose very training will of itself constitute them advisers of the public, as well as of the State and municipality, in regard to the many new enterprises that are coming to the front as the product of American ingenuity and skill; and in this respect, as before, old Columbia will have done her duty. New York is particularly the home of electrical capital and invention. She has more telephones in her business offices than are to be found in most European kingdoms. She has more electric lighting than any other city in the world. One of her companies—built up by Columbia boys—has more motors running in the down-town districts than are to be found in all England. She is the headquarters of the largest telegraph system in existence. She is the centre of the leading electric railway work, and the territory that is commercially hers teems with electrical industries of every character. In fact, while America is by the generous admission of such critics as Professor Ayrton and Professor Forbes, the land where electricity has attained its greatest development, and is, as the London *Electrical Review* remarks, the country that is leading the way and setting the example,—New York, beyond all rivalry, is the one city where all the new ideas, new systems and new inventions can be best studied as they require to be, moulded by the stress of daily use, and subject to the incessant improvement that comes with every increase of knowledge.

Under these circumstances, and without in the least forgetting the good work that has already been set on foot in other places to promote the interests of electricity as a technical profession, it is but natural that we should be pleased with the action of Columbia College. There is, moveover, another view suggested, and that is the effect that will be had on the profession. The electrical engineer is not yet so well recognized as an essential factor in modern life that he can afford to neglect any legitimate chance that offers

to secure the place that belongs to him, and when the officers of Columbia College thus second his claims and determine that with their help his status shall not be lower than is accorded to engineers in any other branch, he may well consider the occasion one for congratulation. In dealing with the questions of the future, the electrical engineer will need all the training and facility he can command, and as the employment of the electric current widens there must go in equal degree a larger ability to meet the heavier tasks. Yet another suggestion arising from the new departure is that, indirectly, it may have its salutary influences on other lines of study in the college. We all know how remarkable in practical work has been the effect of the various electrical services in improving the apparatus that is required for their operation. Telegraphy gave us, if nothing more, new methods of wire manufacture. From telephony have been drawn new ideas in acoustics. Electric lighting has marvellously stimulated steam engineering, and now the electric motor confronts the civil engineer with many a strange difficulty that his highest skill must deal with. It is surely no stretch of analogy to believe that in educational work, also, the new study, as exemplified in the Columbia College experiment, may bring about refined adjustments to the changed conditions, and lift the whole system to a loftier platform.

This, however, is anticipating. At present the details of the proposed course have to be elaborated and much will depend on the lines laid down. Meanwhile it is altogether assuring to know that Professor Trowbridge, of the School of Mines, takes a warm interest and active initiative in the matter, and will have a controlling voice in the settlement of many points. From the action of the faculty and trustees, so public spirited and far-sighted, the brightest auguries as to the execution of the scheme may be formed. If we might venture one word of advice, it would be that the work be begun on a somewhat modest scale, so that it may strike its own deep roots, and then follow its own law of growth and unfolding. It is said that the incumbent for the post to be created has already been chosen, and that the name will be given out in due season. For the first few years at least the success of the course will depend on the worthiness of the instructor and on little else, and therefore the greatest care will undoubtedly be exercised in making the selection. Here, again, we found high hopes on the discretion of the authorities of the College, and are content to await their determination, and to prepare for applauding it.

LIST OF BOOKS ON MINING.

BY PROFESSOR H. S. MUNROE.

THE following list of books on mining has been compiled in the hope that it may prove of service to students of the SCHOOL OF MINES and others. Most of the books mentioned will be found in the library of Columbia College. The list might be made much larger, but it is thought best to include only the more valuable works. While, in general, recent publications have been given the preference, a few old treatises and discontinued serials have been retained on account of their value. Many recently published treatises have been purposely omitted, and doubtless others have been overlooked. Works on economic geology, theory of mineral deposits, descriptions of mining regions and of individual mines, mining reports, etc., are not included in this list.

GENERAL TREATISES ON MINING.

BURAT. Exploitation des Mines. Paris. 1876.
CALLON. Lectures on Mining. London. 1876–1886.
COMBES. Exploitation des Mines. Liege. 1847.
EVRARD. Exploitation des Mines. Mons. 1879.
HATON DE LA GOUPILLIERE. Exploitation des Mines. Paris. 1883–5.
HUNT. British Mining. London. 1884.
KOHLER. Lehrbuch der Bergbaukunde. Leipzig. 1884.
SERLO. Leitfaden zur Bergbaukunde. Berlin. 1884.

MINING MACHINERY.

ANDRE. Treatise on Mining Machinery. London. 1878.
PERCY. Mechanical Engineering of Collieries. London. 1885.
RITTINGER. Berg und Hüttenwesen maschinen auf der Ausstellung zu Paris. Vienna. 1867.

METAL MINING.

CHURCH. The Comstock Lode. New York. 1879.
DAVIES. Metalliferous Minerals and Mining. London. 1880.
DOYLE. Tin Mining in Larut. London. 1879.
EMMONS AND BECKER. Precious Metals. U. S. Census Report. Washington. 1885.

HAGUE. Mining Industry. (Vol. III., Reports Geological Survey of 40th Parallel.) Washington. 1870.
LOCK. Gold; Its Occurrence and Extraction. London. 1882.
PHILLIPS AND DARLINGTON. Records of Mining, etc. London. 1857.
PHILLIPS. Mining and Metallurgy of Gold and Silver. London. 1867.
PUMPELLY. Mining Industries. U. S. Census Report. Washington. 1886.

COAL MINING.

ANDRE. Practical Treatise on Coal Mining. London. 1875–6.
BURAT. Le Matériel des Houillères. Paris. 1861–5.
CHANCE. Mining methods and appliances in the Anthracite Coal Fields. Report AC. Geol. Survey Pa. Harrisburg, Pa. 1883.
DEMANET. Cours d' Exploitation des Mines de Houille. Mons. 1878–9.
DADDOW AND BANNAN. Coal, Iron and Oil. Pottsville. 1866.
HARPER. Coal Mining Plant. 2 vols. Derby, Eng.
HEDLEY. Working and Ventilation of Coal Mines. London. 1851.
HYSLOP. Colliery Management. London. 1876.
PONSON. Exploitation des Mines de Houille. Paris. 1868–71.
SMYTH. Coal and Coal Mining. London. 1875.
THOMAS. Coal, Mine Gases and Ventilation.
WARDLE. Reference Book for Colliery Managers. London. 1880.

ELEMENTARY TREATISES ON MINING.

COLLINS. Coal Mining.
" Metal Mining.
HOPTON. Conversations on Mines. Manchester. 1868.
MERIVALE. Notes and Formulæ for Mining Students. London. 1888.
NIEDERIST. Grundzuge du Bergbaukunde. Prague. 1863.
STEGMEYER. Handbuch du Bergbaukunst.
STOHR. Katechismus du Bergbaukunde. Vienna. 1875.

POPULAR WORKS ON MINING.

LORD. Comstock Mining and Miners. Washington. 1883.
HEUCHLER. Die Bergknappen. Dresden. 1857.
SIMONIN. Underground Life. New York. 1869.

SOCIETIES.

American Institute of Mining Engineers. New York.
Technical Society of the Pacific Coast. San Francisco.
Ohio Institute of Mining Engineers.
Sociedad Minera Mexicana. Mexico.
British Society of Mining Students. Durham.
Cornwall and Devonshire Miners' Association. Falmouth.
Chesterfield and Midland Counties Institution of Engineers. Chesterfield.
Cleveland Institute of Engineers. Middlesbrough.
Iron and Steel Institute. London.
Manchester Geological Society. Manchester.
Midland Institute of Mining, Civil and Mechanical Engineers. Barnsley.
Mining Association and Institute of Cornwall.
Mining Institute of Scotland. Hamilton.
North of England Institute of Mining Engineers. Newcastle-Upon-Tyne.
North Staffordshire Institute of Mining and Mechanical Engineers.
South Staffordshire and East Worcestershire Institute of Mining Engineers. Dudley.
South Wales Institute of Engineers. Swansea and London.
Vermländska Bergsmanna Förenignen. Carlsbad.
Bergmanna Förenignens Sammankomster. Fahlun.
Ingenior föreningen. Stockholm.
Société de l' Industrié Minérale. St. Étienne.
Société des Ingenieurs du Hainant.
Société Industrielle de Mulhouse.
Berg-und Hüttenmännischer Verein für Stiermark und Kärnen. Klagenfurt.
Oberschlesischer Berg und Hüttenmännischer Verein. Berlin.
Schlesischer Verein für Berg-und Hüttenwesen. Breslau.
Vereins Deutscher Ingenieure. Berlin.
Versammlung der Berg-und Hüttenmann. Wein. 1882.
Korpus Gornikh Inzheneroff. St. Petersburg.

MINING JOURNALS.

Colliery Engineer. Scranton, Pa.
Engineering and Mining Journal. New York.
Mining Record. New York.

Mining and Scientific Press. San Francisco.
Colliery Guardian. London.
Mining Journal. London.
Mining World. London.
Iron and Coal Trade Review. London.
Annales des Mines. Paris.
Annales des Travaux Publics de Belgique. Bruxelles.
Revue Universelle des Mines. Liege and Paris.
Les Houillères. Paris.
Le Houillier. Mons, Belgium.
La Houille.
Revista Minera. Madrid.
Repertorio delle Miniere. Rome.
Bergmann. Vienna.
Berggeist. Cologne.
Bergwerksfreund. Eisleben.
Berg und hüttenmannischer Zeitung. Berlin.
Berg und hütten Kalender. Vienna.
Berg und hütten Kalender. Essen.
Erfahrungen im Berg und Hüttenmannischer Maschinenbau und Aufbereitungswesens. Vienna.
Glückauf. Essen.
Jahrbuch für das Berg und Hüttenwesens. Freiberg.
Jahrbuch des K.K. Bergakademien zu Pribram, Leoben und Schemnitz. Vienna.
Oesterreiches Zeitschrift fur Berg und Hüttenwesens. Vienna.
Zeitschrift für das Berg, Hütten, und Salinen Wesens im Preussischenstaate. Berlin.
Zeitschrift für Bergrecht. Cologne.

GOVERNMENT AND STATE REPORTS.

Mineral Resources West of Rocky Mountains. 1867–1876.
Mineral Resources U. S. Geol. Survey. 1882–87.
Production of Precious Metals in U. S., Report of Director of Mint. 1881–1887.
California, Annual Report State Mineralogy.
Michigan, Annual Report, Commissioner of Mineral Statistics. 1877–1887.
Great Britain, Mineral Statistics. Memoir Geol. Survey. London.
" " Report Mine Inspectors. London. 1850 to date.

Nova Scotia. Report Department of Mines. Halifax.
New South Wales. Mining Department, Annual Report.
New Zealand. Department of Mines, Reports.
Victoria. Department of Mines, etc., Annual Report on Mines and Mining Machinery.
" Mineral Statistics, Annual.
" Quarterly Mining Reports.
France. Ministère du Travaux Publics, Statistique de l' Industrie Minerale. Paris.
Germany. Handel Ministerium. Die Baulicher Anlagen. (See also Zeitschrift fur Berg Hütten und Salinenwesen.)
Austria. Montan Handbuch.

Most of the above governmental reports are purely statistical. A few contain descriptions of mining plant and methods. For Mine Inspector's reports, see under Accidents.

INDICES TO PERIODICAL LITERATURE.

REPERTORIUM DER TECHNISCHEN JOURNAL LITERATURE. (Yearly Publication.) Berlin.
INHALT DU TECHNISCHEN ZEITSCHRIFTEN. (Appears quarterly in the Zeitschrift fur das Berg Hütten und Salinenwesen.)
GALLOUPE. Index to Engineering Periodicals, 1883–7. Boston. 1888.
INDEX DEPARTMENT. Journal Associated Engineering Societies. (Appears monthly, and in a revised and enlarged form in the December number of each year.)
INDEX TO SCIENTIFIC AMERICAN SUPPLEMENT. (Just published.)
INDEX TO TRANSACTIONS AMERICAN INSTITUTE OF MINING ENGINEERS. Vol. I. to XV.
SUBJECT INDEX. Institution of Civil Engineers. London.

The Institution of Mechanical Engineers, London; The North of England Institute of Mining Engineers, and many other technical societies publish general indices. For special subjects consult the following treatises.

MINE SURVEYING.

BROUGH. Treatise on Mine Surveying. London. 1888.
BRATHUHN. Markscheidekunst. Leipzig. 1884.
WERNEKE. Mittheilunger aus dem Markscheidwesen. Freiberg. 1887.

HYDRAULIC MINING.

BOWIE. A Practical Treatise on Hydraulic Mining. New York. 1885.

EGLESTON. Hydraulic Mining in California. London. 1878.

VAN WAGENEN. Manual of Hydraulic Mining. New York. 1880.

DRILLING AND BLASTING.

ANDRE. Practical Treatise on Rock Blasting. London. 1878.

DRINKER. Explosive Compounds, Machine Rock Drills and Blasting. New York. 1883.

EISSLER. Modern High Explosives. New York. 1884.

FOWLER. Explosives and their Composition. (Pamphlet.) New York. 1888.

MOWBRAY. Trinitroglycerine. North Adams. 1872.

MAJENDIE. Guide Book to the Explosives Act. London.

INGERSOLL DRILL CO. Catalogue.

RAND DRILL CO. Catalogue.

WELL BORING.

CARLL. Geology Oil Regions. Report III., Penna. Geol. Surv. Harrisburg. 1880.

BEER. Erdbohrkunde. Prague. 1858.

DEGOUSSE ET LAURENT. Guide de Soudeur. Paris. 1861.

OIL WELL SUPPLY CO. Catalogue and Supplement. Bradford and Oil City. 1884–7.

SPON. Present Practice of Boring and Sinking Wells.

TECKLENBURG. Handbuch du tiefbohrkunde. Leipzig. 1886–7.

DIAMOND DRILL CO. Catalogue.

SHAFT SINKING.

GLEPIN. Puits des Mines. Paris. 1867.

JEFFERSON. Shaft Timbering. Chesterfield and London. 1880.

TUNNELING.

DOLEZALEK. Der Tunnelbau. Hanover. 1888.

DRINKER. Tunneling, Explosive Compound and Rock Drills. New York. 1883.

GRIPPER. Railway Tunneling in Heavy Ground. London. 1887

HOOSAC TUNNEL. Commissioner's Report. Boston. 1863.

LORENZ. Tunnelbau. Vienna. 1877.

REPORT OF AQUEDUCT COMMISSIONERS. New York. 1887.
RZIHA. Lehrbuch der Tunnelbaukunst. Berlin. 1867.
SCHOEN. Der Tunnelbau. Vienna. 1866.
SIMMS. Practical Tunneling. London. 1877.
SUTRO, ADOLPH. Mineral Resources United States. Baltimore. 1868.
SUTRO TUNNEL. Report. Washington. 1872.
SUTRO TUNNEL Co. and the Sutro Tunnel. New York. 1887.
WALKER, T. A. The Severn Tunnel. London. 1888.

MINE TIMBERING.

GAETZSCHMANN. Grubenmauerung. Schneeburg. 1831.
JEFFERSON. Mine Timbering. Chesterfield and London. 1880.
JICINSKY. Katechismus du Grubenerhaltung. Mähr Ostrau. 1876.
MAYER. Grubenzimmerung. Mainz. 1843.
SICKEL. Die Grubenzimmerung. Freiberg. 1872.

MINE VENTILATION.

ANDRE. Ventilation of Coal Mines.
ATKINSON. Practical Treatise on Gases Met with in Coal Mines. New York. 1875.
" Friction of Air in Mines. New York. 1875.
BAGOT. Colliery Ventilation.
" Principles and Practices of Mine Ventilation.
DEVILLEY. Ventilation des Mines. Mons. 1875.
FAIRLEY. Ventilation of Coal Mines. London. 1879.
STEAVENSON, A. L. Murgue's Theory and Practice of Centrifugal Ventilating Machines.
WILSON. Mine Ventilation. New York. 1884.

MINE DRAINAGE.

HAUER. Wasserhaltungs Maschinen. Leipzig. 1879.
HAYN. Ursprung du Grubenwasser.
HÖRMANN. Wasserhaltungs Maschinen. Berlin. 1874.
POLE. Cornish Pumping Engines.

HAULAGE, HOISTING AND SURFACE TRANSPORTATION.

DANVERS. Screening and Transport of Coal. London. 1872.
EICHENAUER. Seilscheibengerüste. Leipzig. 1877.
EVRARD. Moyens de Transport dans les Mines. Paris. 1872.

FRAHM. Transport und Verladen der Steinkohlen. Berlin. 1887.
HAUER. Forderungs Maschinen. Leipzig. 1871.
HAVREZ. Winding Machinery.
HILDENBRAUD. Underground Haulage of Coal. Trenton. 1884.
MOISSENET. De l'Extraction dans les Mines du Cornwall. Paris. 1862.
NITZSCH. Fangvorrichtungen. Berlin. 1879.
PERCY. Winding and Over-winding. Wigan. 1882.

ORE DRESSING AND COAL WASHING.

ALTHANS. Mechanical Dressing of Ores and Coal. Reports Judges Group I., Centennial Exhibition. Washington. 1880.
D'ALIGNY. Mechanical Preparation of Ores. U. S. Paris Exposition Reports, Vol. IV. Washington. 1869.
EGLESTON. Rolls for Crushing Ore. London. 1885.
GAETZCHMANN. Die Aufbereitung. Leipzig. 1864–72.
HEBERLE. Aufbereitungswerke in Fahlun. Leipzig. 1873.
HARTMANN. Aufbereitung du Silberhaltige Bleierze. 1858.
KUTSCHER. Aufbereitungsanstalt bei Clausthal. Berlin. 1873.
KROM. Machinery for Systematic Crushing, Screening and Concentrating Ores. New York. 1872.
KUNHARDT. Ore-Dressing in Europe. New York. 1884.
KUSTEL. Concentration and Chlorination. San Francisco. 1868.
LAMPKECHT. Die Köhlenaufbereitung. Leipzig. 1888.
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MOISSENET. Preparation du Minerais d'Etains. Paris. 1858.
MUNROE. Losse[e] in Copper Dressing. New York. 1880.
" Weight, Fall and Speed of Stamps. New York. 1881.
" The New Dressing Works of the St Joseph Lead Co. New York. 1889.
" On the Movement of Solid Bodies in Water. New York. 1888
" A Contribution to the Theory of Jigging. New York. 1888.
" The English *vs.* the Continental System of Jigging. New York. 1889.
NEUBERT. Aufbereitung du Erzemassen. Freiberg.
RIVOT. Preparation Mechanique de Minerais de Plomb de Pontgibaud.
RITTINGER. Lehrbuch der Aufbereitungskunde. Berlin. 1867.

RITTINGER Taschenbuch der Aufbereitungskunde. Berlin. 1867.
V. SPARRE. Theorie der Separation. Oberhausen. 1869.

ACCIDENTS IN MINES.

ATKINSON. Explosions in Coal Mines. London.
BAGOT. Accidents in Mines. London. 1878.
CRESWICK, GALLOWAY AND HOPTON. Prize Essays on the Prevention of Explosions and Accidents in Coal Mines. London. 1874.
DENAYROUSE. Des Aérophores. Paris. 1872.
GREAT BRITAIN. Report of Commissioners on Accidents in Mines. Blue Book. London. 1886.
GERMANY. Hauptbreicht du Prussichen Schlagwette Commission. Berlin. 1887.
HATON DE LA GOUPILLIERE. (Au nom Grisou Com.) Les Explosions du Grison. Paris. 1880.
PERNOLET ET AGUILLON. Exploitation et Reglementation des Mines a Grison. Paris. 1881.
PURDY. Colliery Explosions and Safety Lamps. London. 1880.
RAMSAY. On Laying Coal Dust.
ROWAN. Explosions in Coal Cargoes. London. 1882.
SAWYER. Accidents in Mines. New York. 1887.
PENNSYLVANIA. Reports Inspectors of Anthracite Mines. 1870 to date.
" Reports Inspectors of Bituminous Mines. 1877 to date.

(For Bituminous Reports and later Anthracite Reports, see Part III., Annual Report of Secretary of Internal Affairs.)

OHIO. Annual Reports Mines Inspector.
ILLINOIS. Annual Reports Mine Inspectors.
IOWA. Biennial Reports State Mine Inspector.
GREAT BRITAIN. Annual Reports Inspectors of Mines.
" " Annual Reports Coal Mine Inspectors.
NOVA SCOTIA. Report Department of Mines. Halifax.
VICTORIA. Report Chief Inspector of Mines.

The following works contain bibliographies of mining literature:

SERLO. Leitfaden zu Bergbaukunde.
BROUGH. Treatise on Mine Surveying.

NOTES AND ABSTRACTS.

It has been decided to send to each contributor to the QUARTERLY fifty reprints of his article without charge, the editors holding, however, that the reprints are not desired by those who do not ask for them promptly. Covers, title-pages, or *extra* reprints will be at the cost of the contributor.

It is *proposed* to print with each number of the QUARTERLY a special supplement of alumni and school notes, to be sent only to graduate subscribers. Items for such a supplement, if mailed to the editors, will receive consideration.

EDITORS SCHOOL OF MINES' QUARTERLY.

Officers and Managers of the Association of the Alumni of the School of Mines for 1889.

Officers.—President: F. A. Schermerhorn, '68, 61 University Place, City.

First Vice-President: S. A. Reed, '77, 6 East 54th Street, City.

Second Vice-President: W. B. Potter, '69, Washington University, St. Louis, Mo.

Treasurer: J. K. Rees, '75, Columbia College, also, "Dakota," 72d Street and 8th Avenue, City.

Secretary: P. de P. Ricketts, '71, School of Mines, also, 115 East 79th Street, City.

Assistant Secretary: T. B. Stearns, '81, 2 and 4 Duff Block, Denver, Colorado.

Managers, Group 1: H. S. Munroe, '69, School of Mines; J. C. F. Randolph, '69, 35 Broadway, City; W. Allen Smith, '68, 52 Wall Street, City.

Managers, Group 2: W. de L. Benedict, '74, 32 Liberty Street, City; F. R. Hutton, '76, School of Mines; E. G. Love, '76, 69 East 54th Street, City.

Managers, Group 3: N. L. Britton, '79, School of Mines; W. B. Kunhardt, '80, 35 Broadway, City; S. A. Reed, '77, 6 East 54th Street, City.

Managers, Group 4: A. J. Moses, '82, School of Mines; C. E. Pellew, '84, College Physicians and Surgeons, 59th Street and 10th Avenue, City; W. F. Morgan, '84, Short Hills, N. J.

Class 1 (3 years), Smith, Hutton, Reed, Morgan; Class 2 (2 years), Munroe, Benedict, Britton, Pellew; Class 3 (1 year), Randolph, Love, Kunhardt, Moses.

In view of the scattering and relatively small vote, it was resolved at the annual meeting, "That the President be authorized to appoint, before March 1st, 1889, from the Association at large, a committee of five to select and report to the Association, at its first meeting in the fall, nominations for officers and managers to be voted for at the next annual election."

Practical Application of the Russell Process at the Marsac Mill.

On January 1st, 1889, the Leaching Department of the Marsac Mill will begin treating ore from the Daly mine by the Russell process.

The plant consists of: Four ore vats, each 17 feet in diameter, by 8½ feet deep, with a capacity of sixty-five tons; eleven precipitating tanks, each 10 feet in diameter, by 8 feet deep (two for the precipitation of lead from the solution, four for the precipitation of silver and gold, two for the precipitation of silver from the wash water, and three for the storage of the leaching solution); four rectangular sumps of the following dimensions:

Length.	Depth.	Width.
17 feet 6 inches	2 feet 9 inches	5 feet 10 inches
17 " 4 "	3 " 5 "	4 " 9 "
17 " 5 "	3 " 5 "	8 " 6 "
17 " 5 "	3 " 8 "	3 " 5 "

The first sump is used for storing the lead precipitate; the second for storing the precipitates of silver and gold; the third as a reservoir for the leaching solution previous to returning it to the storage tanks for use over again; the fourth for the collection of the silver precipitated from the wash water. From the first, second and fourth of these sumps, pipes lead to a pressure tank, and from thence the precipitates are forced by a pressure of eighty pounds to the square inch into a Johnson filter press which deprives them of about 40 per cent. of their moisture, after which they are placed in a dryer to prepare them for shipment.

The sodium sulphide and the sodium carbonate are prepared in cast-iron tanks, 7 feet in depth by 3 feet in diameter, and stored in four wrought-iron tanks, 7 feet deep by 3½ feet in diameter.

The cost of this leaching plant, which has a capacity for treating 120 tons per day, is, as shown by the books of the company:

Labor,	$6,100
Pipes, fittings, castings and hardware,	6,200
Lumber,	4,725
Freight, hauling and express,	1,480
Lime, sand, rock and cement,	450
Sundries,	50
Total,	$19,005

The prices paid for the chemicals per 100 pounds, in New York and San Francisco, are: Sodium hyposulphite, $1.65; carbonate of soda, $1.40; caustic soda, $2.90; sulphur, $2.40; bluestone, $4. The quantities used per ton of ore treated, are: Hyposulphite, 1½ pounds; carbonate of soda, 6 pounds: caustic soda, 5 pounds; sulphur, 3⅓ pounds; and bluestone, 5 pounds; a total of 20⅚ pounds, costing 53.35 cents, or, with freight added, about eighty-four cents per ton of ore treated.

The following is a comparison between the Marsac amalgamation plant of 65 tons capacity, and the new leaching plant of 120 tons capacity, as regards apparatus and supplies:

1st. The pan room has twenty seven pans, settlers, agitators, and clean-up pans, while the leaching department has but twenty-one vats, tanks and sumps.

2d. The cost of oil, supervision and repairs is ten times greater by amalgamation.

3d. The belting for amalgamation is 100 times greater, and, owing to the heavy duty it performs, wears out rapidly and has to be replaced.

4th. The total weight of castings in the pan room is 371,000 pounds. The total iron (wrought and cast), used in the 120-ton leaching department, is only 27,000 pounds, a difference in cost of over $17,000. Many of the pan-room castings are being replaced continually, while those used in the leaching department are permanent, lasting as long as the mill.—*The Park Record*, Park City, December 29th, 1888. A. J. M.

Recent New Minerals.

Sperrylite.—Horace L. Wells describes a mineral occurring at the contact of rock and ore in the Vermilion Gold-mine, Algoma, Ontario. There was found in small pockets, in decomposed ore, a quantity of loose gravel and sand from which, on milling, several ounces of a heavy brilliant sand were collected.

After treatment with aqua regia and hydrofluoric acid, there remained only some transparent tin oxide and the new mineral, of which the following description is given:

The grains consist of broken isometric crystals of from $\frac{1}{50}$ to $\frac{1}{500}$ of an inch in diameter, the forms being those of pyrite. The composition is arsenide of platinum, $PtAs_2$, with a slight replacement by rhodium and antimony. H. between 6 and 7. G. 10.602. Color tin-white, powder, black.

Before the blowpipe it decrepitates slightly, melts easily when rapidly heated, but when slowly roasted becomes infusible. In closed tube is unchanged, but yields very readily, in the open tube, a sublimate of As_2O_3. When dropped on red hot platinum foil, melts instantly, forming a blister, and yielding As_2O_3, with little or no odor. Is not easily wet by water, showing a tendency to float, and is only slightly attacked by the strongest aqua regia.

Named after Francis L. Sperry, of Sudbury, Ontario, Canada.—*American Journal of Science*, January, 1889.

Sulphophalite.—W. E. Hidden and J. B. Mackintosh describe a mineral from Borax Lake, San Bernardino County, California, which occurs implanted upon hanksite.

The composition determined is $3Na_2SO_4.2NaCl$. Only three specimens were found, and these were small, sharp, rhombic dodecahedra, with smooth, well-polished faces. The characters given are: Color, faint greenish yellow, transparent; H. 3.5 (approx.); G 2.489; slowly soluble in water, unaltered in dry atmosphere.—*American Journal of Science*, December, 1888.

Edisonite.—W. E. Hidden describes a specimen from the Whistnant Gold-mine, Polk County, North Carolina, in the concentrates of placer-washings.

Chemical examinations by Damour, Mackintosh and Penfield, found only TiO_2, and optical examination by DesCloizeaux made the crystalline form distinct from the other forms of TiO_2, the system being orthorhombic, and the axial ratio calculated

$$\breve{a} : \bar{b} : \dot{c} :: 0.99275 : 1 : 0.92337$$

G. = 4.285.

Named after Thomas A. Edison.—*American Journal of Science*, October, 1888.

Auerlite.—W. E. Hidden and J. B. Mackintosh describe a mineral found in Henderson County, North Carolina, intimately associated with zircon, and often implanted upon it in parallel position.

The composition given is ThO_2, $\left\{ \begin{matrix} SiO_2 \\ \frac{1}{3}P_2O_5 \end{matrix} \right\}$ $2H_2O$, but the ratio of phosphoric acid to silica is somewhat variable.

The characters given are: Tetragonal form, like zircon of the locality; color on a fractured surface, pale lemon yellow, through orange to deep brown red; color on surface, dull, yellowish white; lustre, resembling some varieties of gummite or deweylite, but more resin-like; subtranslucent to opaque; brittle; H. 2.5 to 3; G. 4.422 to 4.766, the dark, orange-red having the higher density.

Before the blowpipe is infusible, becoming dull-brown at a high heat, but orange again on cooling. Readily soluble in hydrochloric acid with gelatinization, but, after ignition, becoming insoluble.

Named after Dr. Carl Auer von Welsbach.—*American Journal of Science*, December, 1888.

Beryllonite.—E. S. Dana describes a phosphate of sodium and beryllium, $NaBePO_4$, discovered in 1886, at the smoky quartz locality, foot of McKean Mountain, Stoneham, Maine, by Mr. Sumner Andrews. The mineral is found loose in the soil, but the original source is believed to be a granitic vein, and the original associates, quartz, feldspars, micas, columbite, cassiterite, beryl, apatite and triplite, all of which are found at the same spot.

The specimens obtained, consist of crystals and fragments, the largest crystal being over an inch across. The crystals are short, prismatic, or tabular, highly modified but with dull and sometimes etched faces, and belong to the orthorhombic system. The cleavages are: basal, highly perfect, macro-pinacoidal nearly perfect, brachy-pinacoidal very imperfect; there is also a prismatic cleavage.

The axial ratios are $\breve{a} : \bar{b} : \dot{c} = 0.57243 : 1 : 0.54901$.

The other characters of the mineral are: Hardness, 5.5 to 6; specific gravity, 2.845; fracture, very perfect conchoidal; lustre, vitreous and very brilliant, pearly on the base; color, white to slightly yellowish, not perfectly clear. The composition is $NaBePO_4$.

Before the blowpipe it decrepitates and fuses about 3 to a clouded glass, coloring the flame deep yellow. It gives colorless beads with borax and salt of phosphorus. It dissolves entirely in hot hydrochloric acid, and the crust of salts obtained on evaporation gives a bright yellow flame, but the spectroscope shows nothing but the sodium line.

There is an apparently columnar structure due to multitudes of microscopic canals perpendicular to the base, which are sometimes filled with fluids or earthy matter; besides these, there are also groups of fine lines inclined to the vertical axis which may be other cavities.—*American Journal of Science*, January, 1889.

Pyrrhoarsenite.—L. J. Igelström describes a mineral of an orange-red color, occurring in the ore of the Sjogrufvan manganese mine (Orebro district, Sweden) in veins and small masses of 3 to 4 c.m. diameter, associated with barite, tephroite and calcite. The masses show a distinct cleavage, and are, according to Bertrand, similar to the Berzeliite, of Langban. H. 4. Streak, orange yellow. Analysis showed the follow-

ing percentages: As_2O_5 with some Sb_2O_5 58.06, MnO 17.96, CaO 18.68, MgO 3.58, Insoluble (SiO_2) 1.02, loss (H_2O) .85, Al_2O_3,FeO traces.

This corresponds to a Berzeliite of the formula $(Mn, Ca, Mg)_3(As, Sb)_2O_5$.—*Groth's Zeitschrift*, 14, 279.

New Sulphates of Iron.

Quenstedtite.—G. Linck, in *Jahrb. Min.*, vol. i. 213, 1888, describes reddish-violet, tabular, monoclinic crystals from Chili. The composition given, is 2 FeO_2H. $8Fe_2(SO_4)_3 + 10H_2O$.

Bückingite, described in the same paper, occurs in dark brown thick tabular crystals belonging to the triclinic system. The formula given is

$$2Fe_2(SO_4)_3 + 2H_2SO_4 + 7FeSO_4 + 60H_2O.$$

Hohmannite.—Described by Frenzel in *Min. Petr. Mitth.*, ix. 397, 423, as occurring with copiapite from Chili, is a chestnut-brown massive mineral with a fibrous structure. H. 3, G. 1.24. The formula given is $2Fe_2O_3$, $3SO_2 + 13H_2O$.

Amarantite described in the same paper, occurs in microscopic crystals of an orange color. The formula given is $Fe_2O_3 2SO_4 + 7H_2O$. A later trial of hohmannite gave a result nearly identical with this, making it probable that the two minerals have really the same composition and are identical, though occurring in a different form.—*American Journal of Science*, August, 1888.

Mazapilite.—Dr. G. A. König describes a new mineral from Mazapil, Zacatecas, Mexico, occurring in deep red to black crystals, believed to be orthorhombic. H. is nearly 7, G. 3.567; composition probably an arsenite of calcium and iron.—*Proc. Acad. Nat. Sci.*, Philadelphia, July 3, 1888.

Horsfordite.—A massive mineral, from near Mytilene in Asia Minor, resembling native silver in color. H. 4 to 5, G. 8.812. An analysis gave Sb 26.86 per cent.; Cu 73 37 per cent.
which corresponds to a compound between Cu_5Sb and Cu_6Sb.—A. Laist and L. H Norton, *Amer. Chem. Journ.*, x. 60.

Rtebeckite—Dr. A. Sauer describes, in *Zeit. Geol. Ges.*, xl., 138, a mineral, occurring in the granite of the island of Socotra, in slender prismatic crystals, black in color, and showing the characteristic cleavage of amphibole. An analysis yielded:

SiO_2	Fe_2O_3	FeO	MnO	CaO	MgO	Na_2O	K_2O
50.01	18.30	9.87	0.63	1.32	0 34	8.79	0.72 = 99.98

—*American Journal of Science*, November, 1888.

Dahllite.—Brögger and Bäckström have described a mineral from the apatite region of Bamle, Norway. It occurs as a rather thin crust, with a rounded lustrous surface and a fibrous structure. The color is a pale yellowish white or reddish yellow, but appears colorless in a thin section; it is translucent and somewhat resembles chalcedony. H. 5, G. 3.053. The formula given is $4Ca_3P_2O_8 + 2CaCO_3 + H_2O$.—*American Journal of Science*, January, 1889.

Lansfordite.—F. A. Genth describes a white, translucent mineral, resembling paraffin, but with a crystalline structure and vitreous lustre, which was discovered by two students of the University of Pennsylvania

as a stalactitic growth at the anthracite mine of Lansford, Schuylkill County, Pennsylvania. A prismatic angle of 76° was measured. H. 2.5, G. 1.54 to 1.692. An analysis gave

CO_2 18.90 per cent., MgO 23.18 per cent., H_2O 57.79 = 99.87 per cent.

The loss of water over H_2SO_4, after twenty hours, was 4.83 p. c., after forty-eight hours 11.70, after a week 26.33, at 110° C. 12.31, at 185° C. 9.76, at a red heat 9.39. The formula deduced is $3MgCO_3$, $Mg(OH)_2 + 21H_2O$.—*Groth's Zeitschrift*, 14, p. 255. A. J. M.

Fresenius Zeit. für Anal. Chem. 1888. 4th heft. S. 507.

From *Bulletin de l'académie royale de Belgicæ.* [3 Sèrie.] 13. No. 3. F. Nelissen.

Use of Sodium formate as reducing flux in blowpipe analysis, etc.

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†

BOOK REVIEWS.

A CLASS-BOOK OF ELEMENTARY CHEMISTRY. By W. W. Fisher, M.A., F.C.S. Clarendon Press Series. Oxford. New York: Macmillan & Co. $1.10.

THIS attractive looking little volume is, as stated by its author, intended as a class-book for schools, to be used in conjunction with experimental lectures and practical exercises. Used in this way, the work might be of some value, but as a class-book for general use, it is not to be recommended, as it leaves altogether too much for the teacher to supply, for the author, in his endeavor to be concise, has so stripped his subject that he has left nothing but a skeleton of dry bones.

The book is lacking in simple experiments that the student can perform himself, without the use of expensive or complicated apparatus, and this is certainly a very serious defect in any work intended for those just beginning the study of chemistry.

The student must be obliged to use his own brains and to think for himself, and no better way to accomplish this can be found than by showing him how he can prove by actual experiment that the statements made to him are facts. One good feature of the book is that so many of the chemical reactions are explained by means of equations, and the fact that these equations not only represent the action that takes place, but also the exact proportions by weight in which the several substances combine, is clearly pointed out to the student.

The first chapter explains the difference between mechanical mixtures and chemical compounds, defines the terms—element, atom and molecule,—and gives the laws of chemical combination. Chapters II.–XIV. inclusive, are devoted to the non-metallic elements, special attention being given in Chapters IV. and V. to the consideration of the properties of water and air. In the remaining chapters, the elements, C, S, Cl, Br, I, N, P, F, Bo, Si and As, are described as well as their most important compounds and the acids derived from them. Chapter XV. treats the subjects of quantivalence, the Periodic Law, and acids, bases, salts and the calculation of formulæ—all in six short pages. The metallic elements are considered in Chapters XVI. to XXVII., brief descriptions of the alkali manufacture, of pottery, and of the production of iron and steel being given. The book closes with an explanation of specific and atomic heat and the physical properties of gases. The publishers deserve much credit for the style in which the book is gotten up, the print and paper being exceptionably good. J. S. C. W.

MICROSCOPICAL PHYSIOGRAPHY OF THE ROCK-MAKING MINERALS. By H. Rosenbusch. Translated by Joseph P. Iddings. 8vo. Pp. xiii. 333. Plates, 26. New York: John Wiley & Sons. $5.00

In a volume, of good paper and clear type, Mr. Joseph P. Iddings, of the United States Geological Survey, has presented to English-speaking geologists through the press of Messrs. John Wiley & Son, a translation of the last edition of Professor H. Rosenbusch's work on the *Microscopical Physiography of Rock-Making Minerals.*

To Mr. Iddings all American students of petrography will acknowledge a debt of gratitude, for, while the original German work will remain a standard for reference and a compendium of details on every point of the science, its immense bulk makes it unwieldy for a beginner, and the language in which it is written, offers great difficulties to not a few would-be learners. If the translation be criticised for a rather close adherence to the German idiom, it must be remembered that it is a work of great difficulty to render in perfect English the meaning of a foreign author, and that a very free translation is also open to criticism. The new work is illustrated with the admirable photo-micrographs of the German edition, and nothing is left to be desired except that photographic processes might be so far perfected as to permit of the reproduction of the natural colors of the minerals.

In size, the new work is very convenient, and though the 664 pages of the original have been condensed into 333 in the translation, nothing appears to have been omitted in the abridgment which is indispensable to the beginner; "the advanced student is referred to the original work." The notes on American localities and occurrences of minerals are especially valuable, and are not to be found elsewhere collated.

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Taking it all in all, the work of Professor Rosenbusch is a model of logical book-making, while it stands as a monumental record of work on a subject which is destined to rank as a science.

F. J. H. M.

EXAMPLES IN PHYSICS. By D. E. Jones, B. Sc. London: Macmillan & Co. 1888. 260 pp. 90 cents

A useful collection of practical problems and questions in physical science used by the author in his own class-work in Aberystwyth College, and in part compiled from the schclarship and general examination papers of a number of the English colleges. The problems are systematically arranged, and wherever it is necessary hints as to the proper solutions are given. A chapter containing answers concludes the book. To students it will prove very useful for purposes of general practice in physical computation, and will be of value to teachers in the preparation of examination papers. W. W. S.

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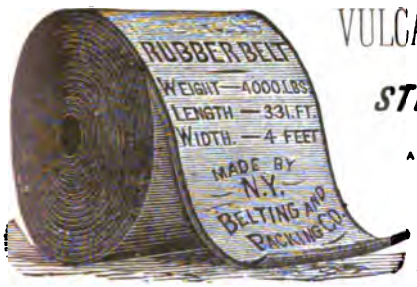

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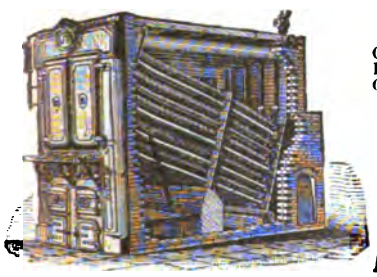

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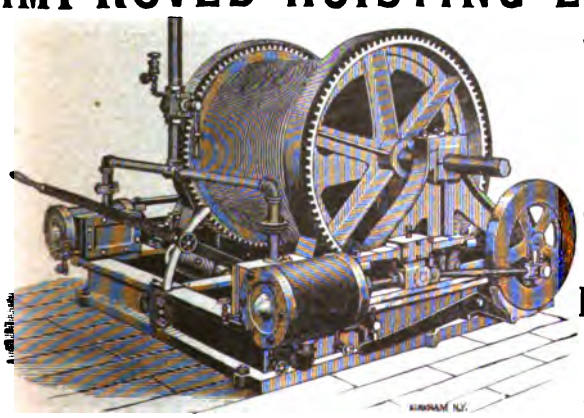

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THE

SCHOOL OF MINES

QUARTERLY.

VOL. X. APRIL, 1889. No. 3.

THE LUNDBERG CASE.

BY ELWYN WALLER, PH.D.

SOME years ago (about 1880) Mr. Gustav Lundberg, agent for Messrs. Hoglund, of Sweden, contracted to supply to the Albany and Rensellaer Steel and Iron Co. a certain number of tons of Swedish pig-iron. In a letter appended to the contract was given the analysis of a sample of this iron (made in Sweden), and it was substantially agreed that the iron supplied should not be inferior in quality to that represented by the analysis. The iron was delivered, but the company claimed that it did not conform in quality to the contract, especially in the percentage of phosphorus. The result was a dispute as to payment, and consequently suit was brought. The case was tried about a year after, before a jury, decided, appealed, and a new trial ordered, which finally took place in 1887. Numerous analyses of the iron were made by different chemists in the country, and the trials brought out voluminous and interesting testimony as to methods of analysis, the discrepancies to be expected from different analysts, the difference between different pigs from the same furnace, etc. Some of the points relating more especially to the questions of analytical chemistry involved have been here collected from the stenographic notes on the case, which were kindly placed at my disposal for this purpose by Mr. Everett P. Wheeler, one of the counsel for Mr. Lundberg. The notes, however, in some few

respects were not absolutely complete, so that a few omissions in the record have been unavoidable.

In the tables of results the sets of samples are designated by letters. In some cases borings were sent to the analysts; in many others, however, certain pigs of the iron were taken to their laboratories, and each analyst took his own borings, so that where two or more analysts are credited in the tables with having had the same sample, they frequently had only borings from the same pigs.

The iron was from three different furnaces, presumably running uniformly, and the pigs from each furnace were designated by a set of letters, cast into each pig. The marks were respectively NB GPH, SBVE and NB ^{B} BK.

In the tables of results is incorporated a brief suggestion of the mode of analysis pursued.

Results for Phosphorus.

In the column headed methods of analysis the first letter indicates the solvent employed at the start. *A* signifies aqua regia or, at least, nitric acid with some addition of hydrochloric. N signifies nitric acid, and Cl Chlorate of potash and hydrochloric acid. Succeeding these *MM* indicates the use of the molybdate-magnesia method, and Cit the citric acid method. The methods will be more fully described later on.

Methods used for the Determination of Phosphorus.

Amount taken.—Most of the analysts used at least five grammes. The amount, however, varied from one to ten.

Solution of the Iron.—The majority of the analysts seem to have used nitric acid alone, though in some cases it appeared that a little hydrochloric acid had been afterward added, and in describing the method the witnesses had forgotten to mention it, as it was regarded by them as unimportant, the hydrochloric acid only being used occasionally to hasten the action. Three used aqua regia as their regular method. Messrs. Garrett, McCreath, and J. M. Sherrerd tried the use of other solvents than it had been their custom to use. No perceptible influence on the result ensued, though Dr. Wuth expressed a positive belief, founded on the observations of Stockmann (*Fres. Zeits.* xvi., 172), that HCl could not be used in the solution of the iron without loss of

phosphorus as PCl_3. On the other hand, several of the analysts declared, as the results of their own experience, that the use of some HCl was admissible, all, of course, agreeing upon the necessity of the predominance of a strong oxidizing agent.

Evaporation.—After effecting solution evaporation to dryness necessarily followed, but in the heating of the evaporated mass to

Phosphorus.

Analyst.	Sample.	Grms. taken.	Method of Analysis.	Furnace Marks. NB GPH	SBVE	NB B BK
S. B. Sharples	a	.....	A MM	0.02	0.041	0.0055
J. B. Mackintosh	b	2	N MM	trace	0.01	0.01
"	"	5	"	0.032	0.032	0.025
A. H. Elliott	c	5	Cl MM	trace	trace	0
"	"	10	N MM	0.0307	0.0223	0.028
"	"	10	A MM*	0.025	0.0223	.....
E. B. Hills	d	.....	A MM	0.027	0.033	0.022
S. C. Eaton	"	1	Eggertz	0.016	0.0039	0.0039
J. M. Sherrerd	e	6-8	N MM	.....	0.038,0.041,0.040,0.0395	.....
P. W. Shimer	"	3-4	N MM	.....	0.039,0.039	.....
A. S. Bertolet	f	5	N MM	0.048	.....	.....
J. M. Sherrerd	"	6-8	N MM	0.0528,0.0544,0.0508	.....	.....
.....	.....	.....	.....	0.0491,0.0499	.....	.....
A. S. McCreath	g	5-10	A Cit	0.0458,0.0463,0.0444	0.0391,0.0382,0.0391	0.0452,0.0458,0.0441
"	"	5	Cl Cit	0.0447	.....	.....
J. M. Sherrerd	"	5-7	N MM	0.048,0.0475,0.047	0.0424,0.0413,0.0367	0.045,0.046,0.0437
A. S. McCreath	h	5-10	A Cit	0.0463,0.0469,0.0455	.....	.....
J. M. Sherrerd	"	6-8	N MM	0.048,0.0486,0.0467	.....	.....
A. S. McCreath	i	5	A Cit	0.0464,0.0463,0.0474	.....	.....
A. A. Blair	"	10	N Cit	0.043	.....	.....
W. O. Wuth	"	5	N MM	0.047,0.047	.....	.....
J. M. Sherrerd	"	5-7	N MM	0.0475,0.0479,0.0467	.....	.....
A. S. McCreath	j	5-10	A Cit	0.048,0.0469	.....	.....
"	"	5	Cl Cit	0.0474	.....	.....
A. A. Blair	"	5	N Cit	0.044	.....	.....
W. O. Wuth	"	5	N MM	0.048,0.048	.....	.....
J. M. Sherrerd	"	6-8	N MM	0.0493,0.0475,0.0470	.....	.....
A. S. McCreath	k	5-10	A Cit	0.0435	.....	0.0402
.....	"	5	Cl Cit	0.0446	.....	0.0407
W. O Wuth	"	5	N MM	0.046,0.046	.....	0.044,0.0438
J. M. Sherrerd	"	5-7	N MM	0.0446,0.0431	0.0363,0.0355	0.0413,0.0403
A. H. Sherrerd and D. W. Humphreys	l	5	N MM	0.0425,0.0419	0.03520,0.358	0.0425,0.0413,0.0430
.....	.....	.....	.....	.....	.....	.....
T. M. Drown	"	5-8	N MM	0.0445,0.0422,0.0441	0.0336,0.0345,0.0344	0.0420,0.0405,0.0414
S. A. Ford	"	4-10	N Cit	0.0456,0.048	0.0394,0.0396	0.040,0.041
W. O. Wuth	"	5	N MM	0.048	0.038	0.047
T. H. Garrett	"	3-4	N Cit	0.049,0.052,0.052	0.042,0.039,0.044	0.040,0.046,0.049
A. S. Bertolet	"	5	N MM	0.046	0.044	0.050
J. M. Sherrerd	"	6-8	N MM	0.053,0.0527	.....	0.0468,0.0503

* Second Method Cairns Quant. Anal., p. 82.

render the silica insoluble, and to destroy carbonaceous material, the practice was very varied, both as to temperature and as to time. The widest difference was between heating for several hours (about 10) to 110° C. (Mackintosh), and heating for a short time to dull red heat (Wuth). Aside from these extremes the time varied from 30 minutes to 3 hours, the temperature from 120° to

165° C. Messrs. Blair and Wuth testified to dissolving in HCl, after the first heating, and again evaporating to dryness.

To recover the small amount of iron, and possibly of phosphorus, which might have adhered to the silica, Dr. Drown ignited after filtering and treated with aqua regia; Messrs. Garrett and Blair expelled the silica by hydrofluoric acid, fused the residue with alkaline carbonate, and added the solution therefrom to the main solution. The other analysts did not testify to having taken any such precaution, and presumably in most cases it was omitted.

Further Treatment.—Beyond this point there was inevitably a divergence, according to the method to be pursued. Messrs. Ford, Garrett, Blair and McCreath used the "citric acid method," or, as some called it, the "acetate method." The iron was reduced by alkaline sulphite, sulphuretted hydrogen passed through to remove arsenic if present, the solution filtered, boiled, and then a portion of the iron reoxidized. For this purpose Messrs. Garrett and Blair used bromine; Messrs. Ford and McCreath used potassium chlorate. Then, after neutralizing with ammonia and adding alkaline acetate, basic ferric acetate containing the phosphorus was precipitated by boiling. The precipitate was dissolved in hydrochloric acid, and citric acid added, followed by magnesium mixture and ammonia.

Both of the Messrs. Sherrerd passed H_2S through the filtrate from the silica to remove arsenic if present, and then reoxidized the whole of the iron. Messrs. Mackintosh and Elliott reduced the iron as above described, reoxidized a portion with potassium permanganate, and precipitated as for the "citric-acid method," but carried the precipitate through by the molybdate-magnesia method (Cairns' second method).

Molybdate Precipitation.—There was a substantial agreement on all sides as to the necessity for effecting the molybdate precipitation in presence of a predominance of nitric acid and nitrates; as to the permissibility of the presence of hydrochloric acid and chlorides there was some difference of opinion and practice. As to the amount of molybdate reagent used, the time the mixture was allowed to stand, and the temperature at which it stood, there was a great diversity of practice. Mr. Eaton (who used the Eggertz method by request of one of the counsel, and took but

one gramme of the iron in accordance with Eggertz's directions*) used 10 c.c. only. 25 c.c. was used by some other analysts, and 100 c.c. by several others. The mixtures were usually allowed to stand for precipitation over night, though some prolonged the standing to 24 or even 40 hours. The temperature employed was sometimes the ordinary temperature of the laboratory, sometimes about 40° C.

Dilute molybdate solution, dilute acidified ammonium nitrate or dilute nitric acid, were used in washing the precipitate.

Magnesium Precipitation.—In some cases the molybdate precipitation had been so managed that the ammonia used for solution left behind a small amount of iron, so that some of the analysts, as a regular custom, passed hydrochloric acid through the filter paper, and then added a small amount of citric acid or of Rochelle salt before adding the magnesium mixture.

Messrs. Drown, Mackintosh and J. M. Sherrerd testified to allowing the ammoniacal solution to stand for some time in order to allow any silica, etc., to separate and to be filtered off before adding the magnesium mixture.

The amounts of magnesium mixture used ranged from 2 c.c. to 25 c.c. From 10 to 20 c.c. were most frequently used.

So far as the testimony went, the magnesium mixture prepared with the chloride (Gooch's formula) was invariably used.

The time allowed for the deposition of the precipitate varied from 2 or 3 hours to 12 or 15. The most common practice appeared to be allowing it to stand over night. The addition of alcohol to the ammonia solution used for washing was mentioned by several as their usual habit.

Testing the Precipitate.—In most cases after the ignition of the precipitate and weighing, it was dissolved in acid and the insoluble silica, if present, filtered off and its weight deducted. Where provision had not been previously made for the removal of arsenic, the solution was tested with sulphuretted hydrogen.

Mr. A. H. Sherrerd, by his assistant, Mr. D. H. Humphreys, carried through a blank ordinary analysis, and deducted the amount so found from the weight of the precipitate obtained.

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* *Vid. Chemical News*, ii. 227.

Resumé of Results on Phosphorus.

Number of Analysts: 15.

Number of determinations: NB GPH, 65; SBVE, 34; NB ^{B} BK, 35.

Maximum variations of different analysts upon the same pigs: NB GPH 0.0419 (A. H. Sherrerd) to 0.053 (J. M. Sherrerd). Diff. = 0.0111.

SBVE 0.0336 (T. M. Drown) to 0.044 (A. S. Bertolet). Diff. = 0.0104.

NB ^{B} BK 0.0405 (T. M. Drown) to 0.050 (A. S. Bertolet). Diff. = 0.0095.

Maximum variations in the same brand:

NB GPH 0.02 [sample *a* (S. B. Sharples)] to 0.0544 [sample *f* (J. M. Sherrerd)]. Diff. = 0.0344.

SBVE 0.033 [sample *d* (E. B. Hills)] to 0.0424 [sample *g* (J. M. Sherrerd)]. Diff. = 0.0094.

NB ^{B} BK 0.0402 [sample *k* (A. S. McCreath)] to 0.050 [sample *b* (A. S. Bertolet)]. Diff. = 0.0098.

Results for Sulphur.

As the case was made to turn chiefly on the percentage of phosphorus present in the iron, many of the analysts made no examination for either sulphur or silicon.

Sulphur.

Analyst.	Sample.	Grms. taken.	Method of Analysis.	Furnace Marks.		
				NB GPH	SBVE	NB ^{B} BK.
S. B. Sharples . .	a	. .	A Dir	trace	trace	trace
A. H. Elliott, . . .	c	5	Cl filtr	none	none	none
E. B. Hills, . . .	d	. .	. . .	none	none	none
J. M. Sherrerd, . .	e	. .	. . .	. . . . .	0.011	. . . . .
P. W. Shimer, . .	"	7	Ev Mn	. . . . .	0.019,0.013	. . . . .
A. S. Bertolet, . .	f	. .	. . .	0.038	. . . . .	. . . . .
A. M. Sherrerd, . .	l	5	Ev Mn	0.0005	0.0008	0.00067
T. M. Drown, . .	"	5–6	Ev Mn	0.024	0.033	0.019
S. A. Ford, ...	"	4–5	A Dir	0.0085,0.0052	0.0102,0.0075	0.0167,0.0166
W. O. Wuth, . . .	"	10	Ev Pb	0.018	0.020	0.023
T. H. Garrett, . .	"	. .	. . .	trace	0.007,0.005	0.011,0.007
A. S. Bertolet, . .	"	. .	. . .	0.039	0.027	0.023
J. M. Sherrerd, . .	"	. .	. . .	0.0074	. . . . .	0.011

In the table of results, under methods of analysis, the letters, A, N and Cl, have the same significance as to the solvents used, as in the phosphorus table. *Dir.* signifies that the precipitation of the barium sulphate was effected in presence of all the iron after solution.

Ev., that the sulphur was set free from the sample by treatment. *Filtr.*, that the iron in this solution was precipitated out by ammonia, and the sulphur determined in the filtrate, with HCl in a suitable apparatus. *Mn*, that the gas thus evolved was passed through a solution of potassium permanganate (Drown, *Am. Chem.*, iv. 423). *Pb*, that it was passed through a solution of lead salt.

METHODS USED FOR THE DETERMINATION OF SULPHUR.

The "direct" method used by Mr. Ford was described by him as having been performed thus: The iron was dissolved in nitric acid, with addition of a little hydrochloric; after effecting solution more hydrochloric acid was added, and the solution evaporated to dryness and heated, the mass taken up with hydrochloric acid, and the solution evaporated until ferric chloride began to crystallize out. It was then diluted, filtered, barium chloride solution added, and the mixture allowed to stand (warm) over night, then filtered, etc., as usual. Mr. Sharples appears to have followed essentially the same method.

Mr. Elliott precipitated the iron with ammonia in the solution filtered from the silica, and in the filtrate from the iron added barium chloride after acidulating.

The evolution method used by Messrs. Drown, Shimer and A. H. Sherrerd is the one sometimes known as "Drown's method for sulphur." It consists in treating the iron in a flask with hydrochloric acid, and passing the gases evolved through potassium permanganate solution; after destroying the excess of permanganate by heating with hydrochloric acid, the sulphur was precipitated with barium chloride. Messrs. Drown and Shimer testified to treating the residue in the evolution-flask with aqua regia, to recover any sulphur that might have been retained.

Dr. Wuth used the same mode of expelling the sulphur from its combination with the iron, but previously filled the evolution-flask with hydrogen, and the evolved gases were by him passed through an alkaline solution of lead. The precipitate, consisting

chiefly of lead sulphide, was fused with alkaline carbonate and nitrate, and in the solution from this fusion, after evaporation to dryness with hydrochloric acid, the barium precipitation was conducted as usual.

Resumé of Results on Sulphur.

Number of analysts: 11.

Number of determinations: NB GPH, 12; SBVE, 15; NB ^{B}BK, 12.

Maximum variations of different analysts on the same pigs:

NB GPH trace (T. H. Garrett) to 0.039 (A. S. Bertolet). Diff. = 0.039.

SBVE 0.0008 (A. M. Sherrerd) to 0.033 (T. M. Drown). Diff. = 0.0322.

NB ^{B} BK 0.00067 (A. M. Sherrerd) to 0.023 (W. O. Wuth and A. S. Bertolet). Diff. = 0.02233.

Maximum variations in the same brand:

NB GPH none [samples *c* (A. H. Elliott) and *d* (E. B. Hills)] to 0.039 [sample *l* (A. S. Bertolet)].

SBVE none [samples *c* (A. H. Elliott) and *d* (E. B. Hills)] to 0.033 [sample *l* (T. M. Drown)].

NB ^{B} BK none [samples *c* (A. H. Elliot) and *d* (E. B. Hills)] to 0.023 [sample *l* (Wuth and Bertolet)].

Results for Silicon.

In the table as before, under "methods of analysts," the first letters are intended to suggest the solvent used. The other abbreviations used will be explained in the fuller descriptions of the methods.

Messrs. Drown, A. M. Sherrerd and Shimer used the method known as Drown's,* which consists in beginning solution with nitric acid, then adding sulphuric in sufficient excess, and dehydrating the silica by evaporating down to concentrated sulphuric acid. Mr. Elliott ignited and weighed the residue obtained by evaporation of the solution of the portion taken for phosphorus. The + sign in the table signifies that that portion of the sample was used for some other determination. Dr. Wuth purified the residue left by evaporation of the first acid solution of the iron,

* *Trans. Am. Inst. Min. Eng.*, vii. 346.

by fusion with alkaline carbonate, solution in hydrochloric acid, and re-evaporation. Messrs. Garrett and Ford determined the silica by loss, Mr. Garrett taking the residue left by evaporation of

Silicon.

Analyst.	Sample.	Grms. taken.	Method of Analysis.	Furnace Marks.		
				NB GPH	SBVE	NB ^{B} BK.
S. B. Sharples, . .	*a*	. .	A	0.72	1.05	0.69
A. H. Elliott, . . .	*c*	5	Cl +	0.979,0.971	1.113	1.192
E. B. Hills, . . .	*d*	. .	. . . . .	0.96	0.9	0.95
J. M. Sherrerd, . .	*e*	. .	. . . . .	. . . . .	0.87	. . . . .
P. W. Shimer, . .	"	1	N Drown	. . . . .	0.841,0.822	. . . . .
A. S. Bertolet, . .	*f*	. .	. . . . .	0.813	. . . . .	. . . . .
J. M. Sherrerd, . .	"	. .	. . . . .	0.961	. . . . .	. . . . .
A. M. Sherrerd, . .	*l*	5 ?	N Drown	1.106,1.120	0.812,0.812	1.26,1.26
T. M. Drown, . .	"	1-1.5	N Drown	1.112,1.152	0.838,0.832	1.237,1.234
S A. Ford, ...	"	2–3	HCl loss KHO	1.065,1.061	0.801,0.781	1.190,1.190
T. H. Garrett, . . .	"	3–4	N loss HF +	1.116,1.107	0.822,0.821	1.239,1.232
A. S. Bertolet, . .	"	. .	. . . . .	1.058	0.769	1.177
J. M. Sherrerd, . .	"	. .	. . . . .	1.078	. . . . .	1.195
W. O. Wuth, . . .	"	2	N HCl fus	1.05	0.77	1.190

the portion taken for phosphorus and, after ignition and weighing, expelling by means of hydrofluoric acid. On the other hand, Mr. Ford took a separate portion, dissolved in hydrochloric acid (Gr. 1.06), evaporated to dryness, weighed the residue, boiled it with KOH solution (Gr. 1.25), diluted with an equal bulk of water, and again filtered and weighed.

Resumé of Results on Silicon.

Number of analysts: 11.

Number of determinations: NB GPH, 17; SBVE, 16; NB ^{B} BK, 14.

Maximum variations of different analysts on the same pigs:

NB GPH 0.813 (A. S. Bertolet) to 0.961 (J. M. Sherrerd). Diff. = 0.148.

SBVE 0.769 (A. S. Bertolet) to 0.838 (T. M. Drown). Diff. = 0.069.

NB ^{B} BK 1.177 (A. S. Bertolet) to 1.26 (A. M. Sherrerd). Diff. = 0.083.

Maximum variations in the same brand:

NB GPH 0.72 [sample *a* (S. P. Sharples)] to 1.152 [sample *l* (T. M. Drown)]. Diff. = 0.432.

SBVE 0.769 [sample *l* (A. S. Bertolet)] to 1.113 [sample *c* (A. H. Elliott)]. Diff. = 0.344.

NB ^{B} BK 0.69 [sample *a* (S. P. Sharples)] to 1.26 [sample *l* (A. M. Sherrerd)]. Diff. = 0.570.

Conclusions.

A fair conclusion from these results would seem to be that as regards *phosphorus*, different analysts having portions of the same pig-iron *may* obtain results differing from one another by about 0.01 per cent., also that in the same brand of iron about the same difference in phosphorus is to be expected.

As regards *sulphur*, when small in amount the differences to be expected between different analysts on portions of the same pig, or between different samples of the same brand, are comparatively great and very irregular, and hence we must conclude either that sulphur is very irregularly distributed through the iron, or that our present methods of determining that element in manufactured irons need careful revision. Probably both aspects of the case require attention.

As regards *silicon*, portions of the same pig in different hands may show results differing from one another by 0.1 per cent. or over; in the same brand the differences may be in the neighborhood of 0.5 per cent.

As to methods of analysis there seems to be no good reason for giving a preference to one over any of the others used by the different analysts. In many cases results agreeing closely were obtained on the same sample by different methods, and further, where the same analyst tried the effect of different methods, his results were essentially the same.

A FEW WORDS IN REGARD TO THE SEWERAGE AND DRAINAGE OF THE VILLAGE OF NEW BRIGHTON, STATEN ISLAND.

By ARTHUR HOLLICK, Ph.B.

Every growing community, at some stage in the course of its evolution, finds that a public water-supply and some system of sewerage have become matters which call for its earnest atten-

tion. Unfortunately, for all except the doctors and undertakers, the former is always the first to be put into operation. Indeed, it is often this alone which forces attention to the necessity for sewers. Just as long as water remains comparatively scarce, and no more is used than is absolutely necessary, its disposal as house-waste does not attract much attention, provided it does not cry out *too* loud and is content to remain out of sight and out of mind in convenient cesspools or to join the storm-water in some easily-accessible watercourse. With the advent of an abundant water-supply, however, the overtaxed cesspools rebel and refuse to hold any more, street gutters are utilized and watercourses become open sewers. The ground becomes saturated and finally some steps have to be taken towards providing sewers. The village of New Brighton has passed through the ordeal of obtaining its water-supply, in regard to which I had a few words to say last year,* and it is now struggling with the problem what to do with the water after it has been fouled. In order to gain a clear understanding of the case it is necessary to know something in regard to the boundaries, topography, geology, population, and present sanitary condition of the village. It is situated on that part of Staten Island which is nearest to New York, where the north and east shores meet at almost a right angle, forming what in the good old times was known as Duxbury Point, but which has been of late years Wimanized into St. George. The corporate limits extend along the water-front from the old Tompkinsville landing, where the neighboring village of Edgewater begins, to the creek at Bodine's Mill, where the village of Port Richmond adjoins—a total frontage of about 3½ miles. The area is about nine square miles, only about one-half of which is thickly populated enough to render sewerage necessary, the remainder consisting of woodland and meadow or large country places. The population is about 16,000, the bulk of which is concentrated near the shore in a belt which extends more or less irregularly inland for a distance of a mile or more. There is a constant slope in the land from the shore upward to the extreme limits of the village, where it attains at one point a height of 300 feet, thus affording every natural facility for perfect drainage. At the eastern and southern boundaries the serpentine rock, which forms the backbone of the hills,

* "A few words about our Water-Supply."—*Staten Island Magazine*, i., 10-16.

appears at the surface. This is extremely porous and absorbs water like a sponge, making a perfectly dry soil wherever it occurs. Over the remainder of the village the ground consists of a mantle of Drift, more or less assorted into layers of sand, gravel and clay, interspersed with erratic boulders. Where the clay predominates an almost impervious soil is the result, while the beds of sand and gravel act as the media for receiving and storing the ground-water. In speaking of the three villages above mentioned, it should be remarked that their dividing lines are purely arbitrary, as there is now one continuous, thickly-settled community, without a break, extending along the shores from the Narrows to a point opposite to Elizabethport, N. J., and this fact must be borne in mind when studying any problems of sewerage or drainage, as the adjoining villages have several natural drainage areas in common, which will have to be taken into consideration sooner or later when the three villages are merged into one municipality—a scheme which already has its earnest advocates. At the present time the sanitary condition of the village is not such as the wealth and intelligence of its inhabitants ought to tolerate. House-waste is permitted to flow into the gutters of many streets, old watercourses serve as sewers for large districts, abandoned wells are often utilized for filth receptacles, while nearly every house has its leeching cesspool and privy vault. Even where sewers have been constructed, they have, in many cases, been made to accomplish only their own immediate and particular piece of work, without reference to future needs or to any proper and comprehensive plan of which they ought to be a part. The consequence is a large trunk sewer, capable of carrying away the sewage from a city of 50,000 inhabitants, is located in an avenue where a five-inch pipe would be ample for all time to come, while a five-inch pipe has been laid through a section of the village which will some day require a large sewer. Private individuals have been permitted to lay sewers through streets where public sewers will eventually be needed, or else to connect their private sewers with the public ones, and to extend their own branches indefinitely, without reference to the capacity of the outlet. Fortunately, there has not been any obstacle thus far encountered which has required more than ordinary engineering experience to overcome. The topography is such that there has been no difficulty in obtaining a splendid fall and free outlet to tidewater, either directly to the shore or else

indirectly along natural drainage-channels. Nor are any difficulties likely to be met with, except those which man himself has either wilfully or ignorantly placed there. Naturally, it is one of the best drained regions in the vicinity, but dams have been constructed across some of the streams in order to form ponds, thus saturating large areas which were formerly dry ground; culverts of insufficient depth have been made to drain low lands, or else such lands have been filled in without draining, or in places the natural drainage has been more or less interfered with in the grading and construction of new streets. In two instances, watercourses were closed up entirely and for considerable distances the streams now flow through artificial channels. Lately, the most serious menace of all has been made an accomplished fact. The Rapid Transit Railroad Company has girdled the entire water-front with its track, building bulk-heads or embankments, and cutting off many of the former sewer outlets by filling in their newly-acquired territory. The natural drainage channels, through which brooks or large volumes of storm-water discharge, they have necessarily provided with adequate outlets, but the right is claimed to treat all attempts at laying sewers through the railroad property to tidewater as trespass, and only to allow such as they may approve. The legal aspects of this question, I believe, have never yet been brought to a test, but I think it must be clear that no such right can possibly exist as that to which they lay claim, otherwise the attempt to sewer the village might as well be abandoned. That this is not a mere piece of sensational verbiage will be readily realized when the fact is appreciated that along the entire water-front there are only two streets which extend to tidewater, and it is clearly impossible to sewer the entire village to these two points. Hence, I shall assume that sewers may be constructed to tidewater by the proper authorities wherever they may be considered advisable or necessary, and whatever plans are discussed will therefore be founded upon this assumption.

The present charter of the village was granted in 1866, at a time when the population did not exceed 10,000 and a water-supply or sewer system was not considered as an immediate contingency. No provision was made for either, and the consequence is that under existing laws the authorities find themselves almost powerless to do what the public health and material prosperity of the community requires. In several localities, where people of

wealth and refinement reside, where sewers can hardly be said to be imperatively necessary, they have been constructed voluntarily on petition of the people, whereas, along the most thickly populated streets, inhabited by the poorer classes, many of them tenants, it has been found impossible to obtain the necessary petition, although sewers have been a manifest need for a long time. The authorities are powerless unless petitioned, and those who need sewers most of all are the very ones that refuse to act. Clearly, then, some further legislation is necessary before anything practical can be accomplished, and it is a matter for serious thought what this proposed legislation shall be. Two schemes have been prominently mentioned. The first contemplates amendments to the village charter, giving the trustees power to condemn land for sewer purposes and also authorizing them to construct sewers wherever the local Board of Health declares that sewers are necessary for the public health, without awaiting a petition from the tax-payers. Such legislation would be a step in the right direction, as it would at once permit the opening of sewers to tidewater without any possible legal complications ensuing. It would also recognize the right of the community as a whole to protect itself against filth and disease, in spite of the opposition or apathy of individuals, and would throw the responsibility largely upon the Board of Health, where indeed the entire burden ought rightly to be placed. The manifest disadvantage of this scheme, however, is that it merely perpetuates the present piecemeal method of construction and does not provide for a comprehensive and complete system. The second proposition is for the appointment of a commission, either chosen by the people or else composed of members of the Board of Health and Board of Trustees, who shall have entire charge of and be responsible for the sewerage and drainage of the village. Their first duty would be to prepare a contour map of the village and profiles of every street. Sewer districts would then be mapped out and the best outlet for each such district determined, irrespective of whether this is through public or private property. It might be that a single street or avenue would constitute a district in itself and a single straight run of pipe to tidewater be all that would be necessary. On the other hand, a large trunk sewer might be necessary in another district, with numerous branch sewers leading to it. This it would be the duty of such a commission to carefully

consider and determine before any work was begun. Let us imagine that such a commission has been duly authorized by law, and that they have already accomplished the preliminary work outlined above. Their troubles will then begin in earnest, for the exponents of the "separate system," and those of the "combined system," will then have the chance to advocate the relative merits and demerits of each. Even the limited experience which the village has thus far enjoyed has been rife with discussions, in which considerable apparent ignorance has been shown, even by those who ought to be well informed on the subject. Some of this is no doubt honest difference of opinion, some is pure unadulterated ignorance, and some is wilful misrepresentation for the sake of interested motives. An impartial presentation of the case, under such circumstances, can therefore be productive only of good.

The combined system starts out with the manifest advantage which attaches to established precedence, not only in the popular mind but also amongst engineers. The glamour of antiquity sheds a sacred light upon it, giving it certain vested rights which immediately place the burden of proof upon the shoulders of any other system appealing for recognition. The Cloaca Maxima of Rome and other similar great works of the ancients are quoted, or else reference is made to the modern sewers of nearly all the civilized cities of the world. The natural evolution of the sewer in any community has also much to be responsible for. It generally begins in the form of a pure stream of water, flowing through the lowest part of some natural water-shed. As the region becomes populated it is used more and more for the purposes of sewerage. Individuals and then whole neighborhoods connect with it, and streets are graded so that the surface-water discharges into it. The sides are walled up in places and the top arched over until our brook becomes in fact a combined sewer, accommodating the refuse of the community as well as the water which it was originally designed to carry. This has been exactly the experience of the village of New Brighton, with the Arietta Street and Jersey Street brooks, and will be with other watercourses unless vigorous and determined measures are undertaken. The experience thus gained is exceedingly difficult to eradicate, and even if a sewer is successfully proposed for such a neighborhood, the people, as a rule, are infatuated with the idea that it must be in the form of a brick tunnel, at least large enough for a man to enter

and of sufficient capacity to carry off house-waste, roof-water, street-washings, etc. From an economical standpoint alone such a sewer is of course disastrous, but when important sanitary measures are about to be carried out the question of expense should not be considered. The health of the community is the only item in the calculation, and if the combined sewer is more conducive to this than any other system that can be devised, then, by all means, let it be the combined sewer. In the first place, it will not do to construct it on a calculation of the *average* amount of work that it will have to perform. It must be so built that it will readily adapt itself to any extraordinary occasion, such as a sudden heavy fall of rain. This means, that in order to meet exigencies that may not occur more than once in one or two years, it must be made many times larger than required for all the rest of the time. The actual sewage of a region, which could be amply accommodated by a five- or six-inch sewer, might, if combined with the storm-water, require a conduit four or five feet in diameter. It will naturally be asked, what are the objections to such large sewers besides the cost of construction and maintenance? In the first place, even if perfectly free from obstructions, they cannot be properly flushed except in time of extraordinary rainfall, which occurs but rarely. In the second place, they are liable to obstruction from materials which enter them through street culverts and other necessary large openings. They are also very liable to abuse on the part of people who imagine that such a sewer is the legitimate receptacle for anything that it is advisable or necessary to put out of sight, from ordinary house-sewage to old hoop-skirts and dead animals. Accumulations of such material occur, forming dams which often entirely block the sewer until they are removed by workmen. At other times they merely partially obstruct, causing pools of sewage to accumulate. In dry weather, when no rain has fallen for perhaps weeks, such pools generate the foulest gases, which, if they do not enter the adjoining houses, find their exit through the culverts and manholes to poison the air of the streets in the neighborhood. Such a sewer becomes, in fact, little better than an elongated cesspool. In the third place, it is very seldom that such sewers are made water-tight, and while the liquid filth percolates through and contaminates the adjacent ground, the solid part remains to obstruct and putrefy—thus entirely subverting the idea of a sewer. The separate or small-pipe

system is essentially one in which sewage and storm-water are provided with separate conduits. It is based upon the principle that all human refuse should be removed from the neighborhood of man's habitations as rapidly and thoroughly as possible, and that the earth and air should be carefully protected from pollution. It is the practical manifestation of modern scientific sanitary ideas. It seeks not to hide or merely store away from sight the material which man has rendered foul or offensive, but to remove it at once in the most thorough, economical and rapid manner possible, before it has a chance to do any harm.

Now, does the separate system accomplish all this? The experience which has been had with it seems to justify the claims of its advocates, and they say, with good reason, that to construct extensive sewers upon the combined system, in the full light of our present knowledge, would be a step backward. The only trouble in connection with the separate system is that its perfect working depends, not upon the principle of the system, but upon the details of construction, which should be carefully and conscientiously supervised. Once properly constructed, it will, unlike the large sewers, practically take care of itself and be of but little expense in the matter of maintenance, except, of course, in case of some unforseen accident or malicious mischief. The pipes should be of glazed earthenware, impervious to moisture and but little larger than absolutely required to accommodate the volume of sewage. For all practical purposes this may be safely estimated at slightly less than the amount of water consumed, which does not vary from day to day to any appreciable extent, except upon Mondays, when the amount is perhaps one-third greater. Hence, knowing the amount of water consumed on Mondays in any given district will give the approximate maximum requirement for the sewer of the same district. If a five-inch main supplied all the water used, and it was all permitted to run to waste, it is manifest that a five-inch sewer would accommodate it all. This seems to be, however, one of the most difficult matters for the average person to appreciate. The next essential is some method for flushing, which is best accomplished by means of an automatic flush tank placed at the highest level or dead end of every branch sewer and at the head of the main sewer. These should be so adjusted as to discharge at intervals of about eight hours, the volume of the flush to be sufficient to fill the

sewer full-bore for a distance of two or three feet, thus carrying everything before it. Finally, some method of ventilation has to be provided, as it is evident that the rush of such a volume of water down a small pipe necessarily displaces a large amount of air which must find a vent somewhere. This is a matter which has given rise to considerable controversy, some authorities claiming that such ventilation ought to be amply secured by means of the perforated covers of manholes, while others advocate branches to the house sewers to run up the outside of the houses along the line. One well-known sanitarian even contends that the public sewer should be ventilated through the soil and waste pipes of the houses, and an alleged patent is claimed for a system in which this method is one of the essentials. With such an arrangement, it will readily be seen that the welfare of the people along the line of a sewer constructed upon such a principle must depend upon the absolute perfection of the plumbing inside their houses—something which is very seldom attained, or, if attained, is liable to impairment sooner or later by ordinary use or ignorant abuse. The houses being all connected, one with another, are extremely liable to be affected by contagious disease. Defects in plumbing are so frequent and occur in so many different ways that it is not surprising they are often overlooked. Certainly, any community which could wilfully tolerate such a perfectly obvious source of danger is not such a one as would be likely to take an intelligent interest in the complicated details of the plumbing inside their houses.

Furthermore, the fact that the sewer air in the small pipe sewers is so purified as to be almost odorless, renders the greatest care necessary in order to prevent its entry into houses. The absence of any foul odor would remove one of the most important warnings of its presence, while the danger would remain. A parallel example is the case of ordinary illuminating gas, which is immediately detected by its odor as soon as the smallest leak occurs. If it were deodorized, as some well meaning parties have proposed to do, the principal safeguard against accidents from it would be destroyed, while the danger would be correspondingly increased. The connection between house and sewer is one of the most important points for consideration in the entire system, and much depends upon its details. Four-inch Y-branches should be provided on each side of the sewer, twenty-

five feet apart. No greater diameter than four inches should be permitted for any house connection, no matter what the size of the sewer may be, so that anything which is capable of passing through the house connection will readily be accommodated in the sewer. It is also far better for stoppages to occur in the connections than in the sewer, as only one house is thus affected, whereas, if the main sewer should become obstructed all the houses along the line would suffer. At some point on the house connection, preferably just inside the house wall, a running-trap should be provided to cut off all sewer air from the house. Many authorities will doubtless say that this will interfere with the perfect mechanical working of the system and they are right; but the sanitarian will at once say that this is something with which he is not concerned. His only duty is to look after the welfare of the inhabitants and to see that their health is properly protected. If in providing what he considers to be the only proper safeguard, the mechanical working of the sewer is interfered with, he says that is something for the civil engineer to remedy. Personally, I am in favor of a four-inch cast-iron vent pipe, connected outside the running-trap and carried up the outside of the house above the roof. This arrangement gives ample ventilation to the sewer, and at the same time does not subject the people along the line to danger from it. There are, of course, numerous other details in regard to manholes, lampholes, etc., which would have to be described and discussed in case the specifications for construction were under consideration. The main object of this article is to present as clearly as possible the sanitary aspect of the subject. In conclusion, it will naturally be asked, what provision, if any, is to be made for storm- and subsoil-water under the separate system. In nine cases out of ten, the storm-water can be best accommodated by allowing the natural water-courses to remain unobstructed, grading the streets to them wherever necessary, and rigidly prohibiting all house-waste or privy connections. In regard to subsoil-water, this may be provided for by means of tile drains laid in the same trenches with the house connections and public sewer. Much good would also be accomplished if care were taken to pack the sewer trench with sand around the pipes and a layer of gravel over this to a depth of about two or three feet. Such a trench would then, in itself, form an excellent subsoil drain for the region traversed by it.

The village of New Brighton is peculiarily adapted for the separate system, as outlined above. A large number of the principal streets slope direct to the shore, thus affording the best possible facilities for disposing of the house-waste through a single small pipe and the storm-water by surface drainage—only an occasional culvert being needed.

A more or less careful study of the several sewer districts into which the village is naturally divided, leads me to say that I consider the majority of the sewers, at their outlets, need not be more than six or eight inches in diameter. In some a five-inch pipe will be ample, while in no district do I think that more than a twelve-inch outlet will ever be required.

METHODS OF MODERN PETROGRAPHY.

BY H. HENSOLDT.

THE importance of the study of microscopical petrography as an integral part of modern geology is now so widely recognized, that no special reference to it is here necessary by way of introduction, especially since this subject has already been admirably elucidated in the existing text-books, and in numerous essays. Barely forty years have elapsed since Sorby prepared his first rock-sections, and already the researches of an army of indefatigable workers have resulted in an amount of literature, the mastering of which, even in its most essential features, taxes the endurance of all but the most persevering. The microscope is certainly destined to play a prominent part in the geology of the future, and it is safe to predict that before the lapse of another decade no student of geology, mineralogy, or agriculture; no progressive mining engineer, architect, or chemist, can afford to ignore it.

Yet it would be folly to overlook the fact that we still have in this country a large and influential body of workers, comprising most of the geologists of the older school, which is holding aloof from this essentially modern study, and which, by disallowing its claims as an educational factor, or manifesting a contemptuous indifference towards it, is in a great measure responsible for the

comparative neglect and lack of progress which it has hitherto experienced on this side of the Atlantic.

These men represent an old and expiring order of things. They live in a past when geological information was slow to accumulate and the methods of research were in many essential points totally different from those of the present. The most gifted among them established reputations a generation or two ago, when the microscopical investigation of rocks was not even dreamed of; and, neglecting to pay much attention to the new science when it did arise, or to keep pace with its progress, they allowed too much time to elapse to catch up with it without an enormous effort, thus coming to regard it as an unwelcome innovation, and contracting a natural prejudice against it. These skeptics remind one of the old-school physicians, who still refuse to work with the microscope—who disdain to listen even to what they term new-fangled theories, and still persist in prescribing medicines that were in vogue fifty or a hundred years ago. Their's is a self-imposed blindness, for it may be reasonably presumed that the majority cannot help being aware now of the untenableness of their position; but having once compromised themselves by an attitude of hostility or indifference, they cannot now be induced to acknowledge their error. They represent the ultra-conservative element to be found in every rank or profession, whether scientific or otherwise, the element which is opposed to innovation *per se*, and will fight to the last ditch rather than become reconciled to a new order of things. Thus the aged Wellington scornfully refused his consent to the introduction of percussion muskets in the English army, remarking that his soldiers had beaten the French with the old flint-locks before, and could do it again.

Another of the reasons why microscopical petrography is making little or no headway in this country is the want of teachers who are able to render this science attractive to their pupils, and to inspire them with that degree of enthusiasm for it which is requisite for a permanent attachment. In Germany there is now no university so small or so poor but it has its regular instructor of lithology, whose selection is determined not merely by his knowledge of the subject, but by his ability to teach it; and who, therefore, invariably succeeds in gathering around him a number of eager disciples. A good teacher of petrography is *eo. ipse*, a "rara avis," for no other department of modern science embraces

so wide a range of difficult studies. Optics in its most difficult aspects, crystallography, mineralogy, chemistry, geology, and microscopy, are all brought into requisition; and if the lecturer be at home in all these, and a veritable Rosenbusch in petrographical lore, his knowledge will avail him little if he has no teaching talent.

In this country only a few of the leading colleges have as yet thought it fit to open their doors to this new science, and with great reluctance, as it were, driven more by the force of European example than a conviction of its importance. Such instruction as they do offer is administered by persons who, with very few exceptions, are singularly unqualified for the task, being either deficient in knowledge or devoid of that talent for interpretation which, in the teaching of so difficult a science, is of primary importance. Young men, whose knowledge of petrography at best equals that which the average upper-class boy of a German Realschule cannot avoid acquiring during the general course of his training in the rudiments of natural history, are here gravely engaged as class-instructors, with the result that even those students who might, under able hands, have developed into enthusiastic workers, come to regard petrographical science not merely with indifference, but with positive aversion.

True, a number of these would-be petrographers have been to Germany, where for a 'semester' or two they attended the lectures of Rosenbusch or some other eminent lithologist; but strange to say their sojourn in foreign climes appears to have benefited them little, for as a class they have accomplished, if possible, even less than their home-taught colleagues. To have been with Rosenbusch is not equivalent to being a petrographer, although by many this seems to be tacitly taken for granted. The time spent in Germany by the student is, in most cases, too short to prove of real benefit; and even a Rosenbusch cannot accomplish much where there is an almost total absence of preliminary training. The writer has had opportunity of forming an estimate, in several instances, of the qualification of men who pointed with no little pride to the fact of their having "completed" their knowledge at the fountain-head of petrographical philosophy, viz., under Rosenbusch in Germany. All they appeared to have learned was to distinguish, by means of the polariscope, quartz from feldspar in moderately thick sections, orthoclase from plagioclase, hornblende from au-

gite or biotite, provided the minerals were well characterized; a little something about extinctions and angle-measurements—how much or how little their own conscience alone will tell them—and all the rest was confusion. They had equipped themselves with quite a little arsenal of optical and other apparatus, which they believed to be indispensable for this thing or that in the line of their "work," though for what they could not by any means clearly explain.

The want of a reliable text-book in the English language is another of the causes to which the backwardness of petrographical science in this country must be attributed. The works of most of the European petrographers are accessible only to those who have thoroughly mastered the German language. Rosenbusch's great "Mikroskopische Physiographie der petrographisch wichtigen Mineralien," and his "Mikroskopische Physiographie der massigen Gesteine," which are now almost universally regarded as the petrographer's *vade mecum*, are not elementary text-books in the ordinary sense, as they presuppose a vast amount of knowledge, for the acquirement of which little facility has been hitherto offered in American high-schools and colleges. These books are perfectly unintelligible to the student who turns to them without the necessary preliminary discipline, unless, indeed, he has the benefit of an exceedingly able teacher. Nevertheless it is of primary importance that they should be accessible to all, and Mr. J. P. Iddings, by his recent translation of the first-mentioned of the two, which, it is to be hoped, will soon be followed by that of the second, has rendered a great service to the cause of petrography.

What is needed perhaps more than anything, is a truly *elementary* text-book or primer, a book which can be understood without difficulty by every well-educated person, and which does not presuppose more scientific knowledge than the average high-school graduate is likely to possess. It should be free from technicalities and all tedious detail; indeed, its chief aim should be the popularization of petrography by endeavoring to render its study as attractive as possible. Such a work could be written in simple language without any sacrifice of scientific accuracy or precision; and though it would necessarily lack in thoroughness and completeness, and would not, perhaps, answer as a text-book for advanced students, yet it would be of incalculable value to begin-

ners, by affording them an easy introduction to petrography, and smoothing the way for more serious study later on. Let us hope that such a text-book will soon be forthcoming.

II.

Rock Sections and How to Prepare Them.

The writer, who for a number of years has been devoted to the study of petrography, and who has acquired some experience in the preparation of microscopic objects, has been frequently consulted in reference to the methods employed by him in the production of thin sections of minerals and rocks. When reminded of the fact that directions how to prepare rock-sections could be found on such and such a page of Rosenbusch's, Hussaks', or Rutley's works, inquirers generally reply that they are well aware of it, but have failed in obtaining satisfactory results by following the advice there given. A great deal of this non-success is of course due to the want of skill or practice on the part of the operator; but not a little must be attributed to the unsatisfactory character of the directions referred to.

Efficiency in the preparation of sections can only be acquired after a prolonged experience in the many processes which it involves, and only by those who are possessed of the necessary degree of patience and perseverance. The difference in the quality of the sections produced by a professional preparer and those made by the average amateur is so great that a comparison is almost out of the question. Why is this? It is due to the fact that the professional preparer follows methods which his own experience has gradually led him to adopt, methods which are constantly varied or modified by new exigencies; and that he has the advantage of that manual skill which arises from constant practice, while the amateur puts his entire faith in the pages of Rosenbusch or Rutley, and thinks he can make sure of success by religiously following the directions there given. Now neither Rosenbusch nor Rutley have ever made a specialty of the preparation of sections, and it is doubtful whether the world would have ever heard anything of these men if their reputation had depended upon their skill as lapidaries. They may have personally cut and ground hundreds of sections, but whether these were large, uniformly thin and well mounted is much to be doubted. Such

observers are often satisfied if a section is merely transparent around the margin, as long as it shows what they wish to see; uniform thinness or size are secondary considerations, and the style of mounting in particular is of no great consequence in their eyes. The directions which they have given are admirable as far as they go, viz., they will be found reliable in all cases where high-class finish, external beauty—in fact most of the qualities which enhance the value of a slide and make it an object of art as well as of scientific interest—are not required; but they are not sufficiently explicit for unskilled experimenters, and leave the student unacquainted with a number of important processes, without a knowledge of which no superior results can be hoped for. Quite a volume might be written on the art of section-cutting, and if Prof. G. H. Williams, in a little essay entitled "Modern Petrography," gives utterance to the following strange sentence—"This process (the preparation of rock-sections) is by no means as difficult or tedious as it might at first appear, or indeed as it is described by Rutley and some other authors," and then goes on to give the sum total of what he considers necessary to know on that head in about two small pamphlet pages, the writer who, during the last eight years has prepared at least ten thousand sections, can only record his astonishment. According to Prof. Williams, about all the student has to do is to get hold of a rock-chip and grind it thin with emery. As well might an artist say that all one has to do in order to produce an oil portrait is to get a piece of canvas and paint it. The very drawback about Rutley's description (which covers fifteen pages) is that it is not half full enough, but leaves the student to discover a great deal by painful experience and after much loss of time. Prof. Williams also asserts that the condition of the surface of a section is of no great importance, as "all unevennesses disappear when it is imbedded in Canada-balsam." This may be cheerful news to those who experience great difficulty in obtaining a good surface, but nothing could be more erroneous. While an absolute polish is unnecessary, and in most cases even to be avoided, yet a high degree of smoothness which can only be obtained by a careful application of the finest grades of washed flour-emery is an essential requirement of a good section. Rough and scratched surfaces, in spite of the use of Canada-balsam as a mounting-medium, give an abnormal and misleading aspect to the mineral constituents, especially when high powers of magnification

are resorted to. Such preparations are comparatively useless for purposes of real investigation.

A reliable account of how to prepare sections of minerals and rocks can only be expected from one professionally engaged in such work, and the reason why it has not yet been forthcoming is because professionals are naturally reluctant to disclose their methods. In the opinion of the writer, however, there is no real ground for such reticence, for the majority of petrographers, though anxious to learn all they can on this subject, will continue, in order to save time and trouble, to have their section-work done by skilled lapidaries.

In the continuation of this article the writer will explain the methods employed by him in the cutting, grinding, and mounting of sections, with special reference to difficult cases, and will give a description of such machinery and appliances as he considers essential to successful work. The following will be some of the chief points for consideration:

1. The grinding bench; how it should be constructed.
2. Tools used in cutting, grinding, and polishing rock-sections.
3. How to charge diamond-saws.
4. Emery and other grinding materials; their selection and application.
5. Preliminary treatment of rock-chips.
6. Methods of slicing, grinding, and obtaining smooth and level surfaces.
7. Methods of treating soft, brittle or exceptionally opaque specimens.
8. Processes of cleaning and mounting sections.
9. How to avoid air-bubbles or expel them if present.
10. Definition of good and bad workmanship; how to become an expert lapidary and skillful microscopist.

(*To be continued.*)

WESTERN UNION TIME SYSTEM.

F. R. BARTLETT, C.E., and R. P. MILLER, C.E.

In New York City, standard noon time is daily distributed free by the dropping of an electric time ball, placed on the top of the

Western Union Building, corner of Broadway and Dey streets. There is also a distribution, through the instruments in the offices and stores of subscribers, of a continuous service by the system of James Hamblet.

The Time Ball.

The diameter of the ball is forty-two inches, and its weight one hundred and twenty-five pounds. It is composed of a dozen thin vanes of copper (see Fig. 1), half being crescents and half semi-circles, radially disposed around two iron rings, into which are cut three grooves to fit corresponding guides on the iron flagstaff,

Fig. 1.

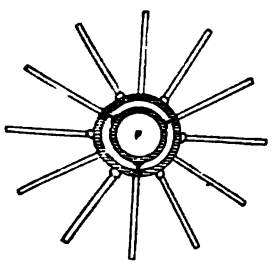
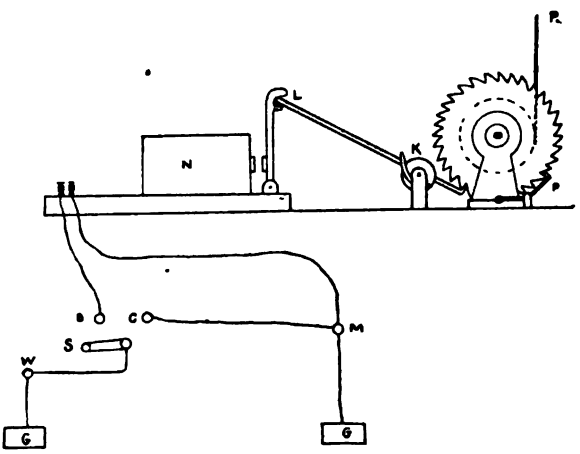


Fig. 2.



F. The ball is raised to the top of the staff (22 feet in height, the whole being 282 feet above mean high water) by means of a rope which passes over a pulley at the top of the pole, thence down through the roof to a drum on the inside of the building (Fig. 2). Five minutes before noon the ball is raised half way, and held by a spring, P, fitting into the ratchet, firmly attached to one end of the drum. A signal from Washington, to insure an uninterrupted line, is received two minutes before noon, and the ball is raised to the top. It is now held in position by the short arm of a lever engaging in the teeth of the ratchet; the long arm being held by a small standard, L, attached to the armature of a strong electro-magnet. The electro-magnet is operated directly by the clock in the Naval Observatory at Washington, but the

connection is not actually made until within a few seconds of the time of discharge, a comparison of the local clock having been made the previous minute. In this way an accidental discharge rarely occurs. At the instant of noon the circuit is completed and the armature, with its attached standard, attracted; the lever being released the lower end is pressed outward by the ratchet and held away by a suitable spring, K. The drum is thus set free and the ball drops at the instant of noon. In falling it slides down three iron guides, and is received by six rubber plungers which enter six corresponding cylinders attached to the ball, forming air cushions for the arrest of its motion without shock. The accuracy attained in dropping the ball, generally is within three-tenths of a second of correct time in fair weather; but if cloudy weather prevail for five or six consecutive days, preventing astronomical observations, the error may reach a second.

The Western Union Standard (made by Howard) is daily compared with that at Washington by means of a common Morse Chronograph, which is brought into the circuit one minute before the ball is brought into the same circuit, the latter operation taking place three or four seconds before noon. The chronograph tape receives the indentations due to both clocks side by side and the interval between those corresponding to the same second of both clocks, or the error of the local clock is read by a glass scale. During the interval of three or four seconds before noon, the current from Washington ceases; the electro-magnet holding the lever and ratchet is then switched into the circuit and the current resumed at exact noon, dropping the ball. Fig. 2 also shows switch, S, for cutting the ball out of circuit. W is Washington, M chronograph, and G the ground.

The Striking Clock.

The distribution of time at all hours to different parts of the city is accomplished automatically by the local clock and its electrical connections. By suitable discharges in the local clock (see "clock") the following signals are transmitted to the various relays and sounders on the line, viz.: the beats, except when otherwise specified, take place on every even second, omitting the fifty-eighth; they cease twenty seconds before each fifth minute, the quarters excepted, and are resumed at the beginning of the five minutes; they cease for three-fourths of a minute before

the quarters, the hour excepted, begin, at the beginning of the first second of the quarter, to strike single beats for the hour, then double beats for the quarter, and cease again until the beginning of the first second of the next minute; and finally, they cease for one and three-quarter minutes before the hour, beat one at the hour and cease until the beginning of the first second of the second minute after the hour. To accomplish this the beats, except those at the hour and the quarters, are transmitted directly from the local clock, the exceptions being provided for by a separate striking clock, which is discharged by one of the quarter-hour discharges, in connection with a minute discharge in the local clock.

The circuit being completed by the local clock, the armature (Fig. 3) is attracted downward and the arm, A, connected to it, moves to the left until checked by the arm, T, at its lower extremity, striking the periphery of the disc, E. A pin on A presses the arm, B, outward, thereby withdrawing the supports of the two segments, C and D, at E, and these drop into their respective snails, G and H. When B moves to the left it releases the pin on E and the disc, E, revolves until this pin strikes the arm, T, which had previously struck the disc, and thereby checking the revolution of E, to prevent its attachments from interfering with the segments until these are dropped. The piece, E, consists of three discs, c, v, and l, Fig. 4, mounted on the same axis, t, which is connected with the train, with the largest disc adjacent to the clock. It has two pins, d and r, attached to it as shown—d being for the purpose of checking or releasing the piece, and r, for picking up the teeth of the segments. The piece, B, has an elbow fastened to it (near E of Fig. 3), one arm of which is perpendicular to the plane of the paper; this supports the smaller segment when at rest, the larger segment being supported by a projecting tooth of B. When the segments are released they drop into their respective snails and upon T resuming its former position, by the breaking of the current, the piece, E, revolves, and the arm, B, being held far enough to the left not to obstruct d, the pin, r, Fig. 4, begins to pick up the teeth of the larger segment. Each tooth of the larger segment, as it is picked up, is held by a spring pressing the projecting tooth of B into the spaces of the teeth of that segment. While this projection is in the upper teeth, the arm, B, cannot move far enough to the right to allow the elbow to enter the spaces of the

smaller segment; so that each time that a tooth of this segment is picked up it falls back again until the projection enters the last and deepest space of the larger segment, when B moves further to the right and the elbow now supports the teeth of this segment as they are picked up. A spring, S, Figs. 3 and 4, stiffened by a bar of brass, is insulated from the clock by being attached to a piece of gutta percha, P, the latter being mounted on an axis

FIG. 3.

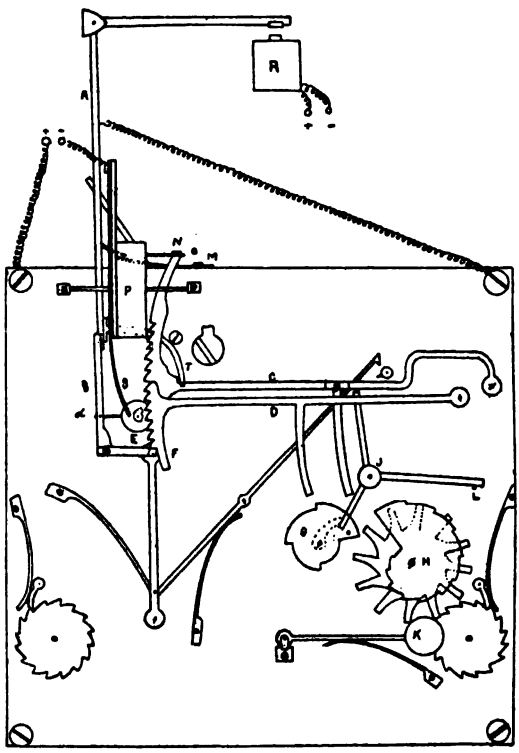
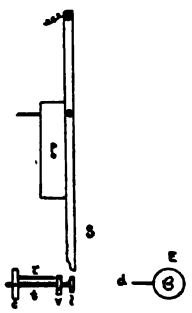


FIG. 4.



raised from the surface of the clock. This piece has a pin on the rear and upper side which is pressed upward by a spring, M, and another pin, O, on the side pressed downward by a stronger spring, N (projecting forward from rear of clock), against the underside of which spring abuts the top of the larger segment when this is completely raised. When the segments have dropped, N presses this pin downward and the lower part of P moves outward and

the spring, S, takes its position in front of the outer disc, l, until the larger segment is raised; this raises N and the spring, M, pressing upward on the pin in the rear of P, causes the spring, F, to oscillate back in front of disc, v, where it remains until the smaller segment is raised. When this occurs, the elbow on B slides under the last tooth, B moves to the right and locks the train. The outer disc, l, has one projection, while the inner, v, has two; the clock and spring, S, being in the same electric circuit which is closed when the projections of these discs impinge against the spring, S, and accordingly, when the larger segment is raised (S being opposite l), the circuit being closed once in a revolution, one beat only is given; and when the smaller is raised (F moving to v) a double beat is given.

The larger snail is composed of the peripheries of twelve circles, the smaller of four; the larger snail dropping from one or more up to twelve teeth, the smaller from one up to three (when dropping into either of the outer peripheries the same tooth is raised). When, therefore, the larger segment is raised the hour is struck, and when the smaller is raised the quarters are struck; with the exception of the exact hour, when a single beat only is given. To accomplish this result, a device, J, is brought into play, which consists of three arms, fastened to a disc free to move on its axis. When at rest it is supported by a pin, L. After the third quarter, the quarter hour snail revolves, and a pin on it presses against the lowest arm of J, rotating the piece until the uppermost arm is brought immediately underneath the projecting part of the larger segment screwed to the main piece at that point. When now the supports of the segments are withdrawn at E, the larger segment receives an additional support and fails to drop. The arm, A, moving to the left, the small projection on it pressing down on the pin on the rear of P, the spring, S, takes its position in front of l, and upon the release of the revolving piece, F, a single tap is given before F resumes its normal position. The hour being past, the pin on G moves beyond the arm of J, and that piece resumes its original position. The remaining parts belong to the clock movement. The arm underneath G, revolving once an hour, moves one of the twelve teeth of a wheel, underneath and attached to H, a twelfth of a revolution. A disc attached to the end of a bar, free to move about one extremity, is pressed by a spring between the teeth of that wheel. When H

revolves this is pressed downward and, when the tooth raises, is pressed between two succeeding teeth.

The electric currents necessary to the operation of the system are furnished by an Edison dynamo, and where the current is more than sufficient to operate the parts, resistance coils are introduced.

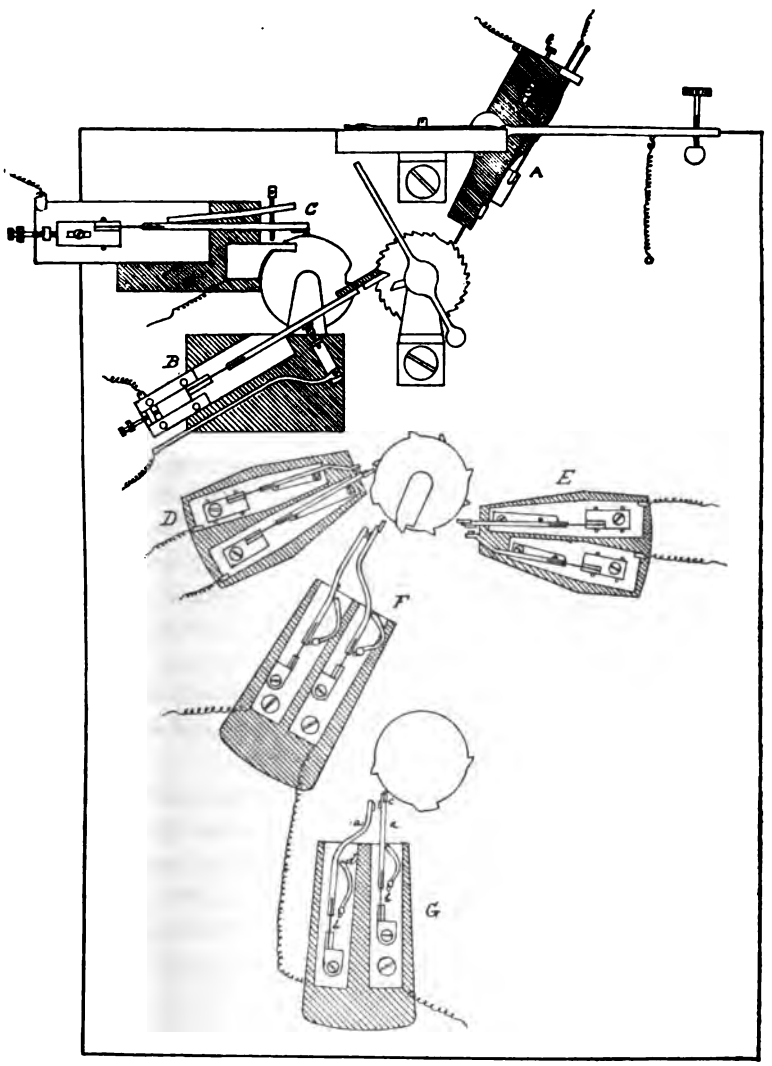
The controlling standard clock is an ordinary astronomical clock of superior workmanship and supplied with the most approved appliances for governing its movements. The works are as simple as the various requirements would allow, and are run by two weights which keep them going for a week. The great wheels on the same arbor as the weight drums (or going barrels), drive a system of wheels turning respectively once in twenty-four hours, once in one hour, in five minutes and in one minute. As all these wheels turn in the same direction (that of the hands of a watch) there will be two intermediate wheels, supposing that the wheel following the centre or hour wheel drives both the five-minute and the one-minute wheels. The arbors of the four main wheels extend beyond the front clock plate and have attached to them the cam-wheels, which open and close the circuits operating the various relays. The movements of the clock are regulated by a Dennison double three-legged gravity escapement and a mercurial compensating pendulum. The works are protected from dust and atmospheric moisture by a wooden case.

The rate of the clock when steadily gaining or losing is regulated by the addition or removal of small weights on the top of the pendulum bob.

The circuits operating the relays and the shunts are opened and closed by what we shall call the clock attachments. They consist essentially of two parts—the cam-wheels, attached to the arbors of the main wheels of the clock, and the springs, two in each case, insulated from each other, which are brought together by the cams on the wheels as the latter revolve on their axes. The cam-wheels are plain, solid brass, with as many cams as is required in each individual case. The springs consist of small brass bars (a, a) attached by means of short steel springs (b, b), in the manner shown (Fig. 5), to projecting pieces of small brass slides. The brass slides are screwed to larger brass plates mounted on a hard rubber plate, which is fastened to the clock frame. In every case one of the springs projects beyond the other, and it is this one which is

lifted by the cam. The end of the projecting spring is furnished with an ivory tip, c, to insulate it and to diminish friction, whilst

FIG. 5.



the end of the other spring has attached to it a small piece of metal, not readily oxidized, to secure a clean metallic contact when the two springs are brought together. The brass plates to which the slides are screwed have attached to them adjustable stops, d, which

prevent the springs from falling too far, and arrest vibration after the springs have dropped from the cams.

According to the degree of accuracy required, the brass slides carrying the springs are more or less nicely adjustable by loosening their set screws and moving back or forward by hand or by adjusting screw. It is evident that two adjustments in these attachments are desirable, one in the direction of the springs, to secure a good bearing between the spring and cam, and one at right angles to it, to secure contact at the proper instant. The former is accomplished by hand or a screw at the end of the slide, the latter either by screw or by an adjustable stop.

The position of a spring with reference to its cam-wheel is also of importance. It should be so placed that there is the least friction and the quickest release. A little consideration will show that this would be at an inclination to the cam surface of about forty-five degrees.

In the two-seconds attachment, A, the spring rests against a steel pin projecting from a brass plate. The wheel which is attached to the minute-wheel of the clock is made of thin steel plate and has 29 teeth or cams and one vacant space. The teeth or cams act against a jewel at the end of the spring and lift it from the pin, thus breaking the circuit. The brass plates to which the spring and the pin are respectively attached are insulated from each other by being mounted on a hard rubber plate. This rubber plate is supported by an axis resting on the clock frame and an angular arm projecting from the same. It is kept steady by a long brass arm fastened to the front of the vulcanite or hard rubber plate. A screw passing through the end of this arm and abutting against a pin fastened to the clock frame prevents it from moving downwards, and a spring prevents motion in the opposite direction. As this attachment requires delicate adjustment, a screw, e, and a spring are applied, which give an up and down adjustment, whilst the screw at the end of the long arm serves for adjusting at right angles to the first.

The minute attachment, B, differs from the others in that there is only one spring and that the circuit is opened instead of closed each minute. In lieu of a second spring there is a brass screw, against the head of which the spring rests, and from which it is raised every minute by a cam attached to the arbor of the minute-wheel of the clock. This screw, moving in a fixed nut, serves

also as an adjusting screw, with which, and the screw at the end of the spring, the latter can be very carefully set.

The five-minute attachment, C, is like the one-minute attachment, in that there is but one spring. In its details of construction and mode of action, however, it differs materially from the latter. The abutting screw in this case passes through the brass bar of the spring and is dropped and raised with the spring, making contact by dropping against a little brass shelf and breaking again by being lifted from it. In other respects the spring does not differ essentially from the general form. But the wheel operating this spring is quite the reverse of the others; in place of a cam, it has an indent for twenty-four degrees of its circumference. As long as the stud at the end of the spring rests on the circumference of the wheel the screw of the spring is lifted from the shelf and the circuit is open; but when the indent gets below the stud, during the revolution of the wheel, the spring drops and with it the screw, closing the circuit by abutting against the shelf. As the whole wheel revolves in five minutes, the circuit is closed for twenty seconds and the wheel is so set that this is done at the end of every five minutes.

The quarter-hour shunt, D, the quarter-hour striking attachment, E, which are exactly alike, and the special signal attachments, F, G, are all of one kind, differing only in detail of construction. The adjustments are all made by hand and their mode of action is the closing of a circuit by bringing the two springs in contact. The cam-wheels operating them, however, require separate descriptions. Three of them are attached to the arbor of the hour-wheel, and the fourth to that of the twenty-four hour wheel. Those operating the quarter-hour attachments have each four cams, placed equally distant on the wheels. The cams operating the striking attachment are only so large as to hold the springs together for a few seconds before and after the quarter-hour. Those controlling the quarter-hour shunt, on the other hand, are large enough to close the circuit for forty-five seconds before and after the quarter-hour, and that which acts at the even hour must keep contact for one minute and forty-five seconds before and two minutes after, that is, it must be a little over 22° of arc. As has already been intimated, the special signal attachment consists of two sets of springs, one operated hourly and the other three times in twenty-four hours. One spring of the former set is connected

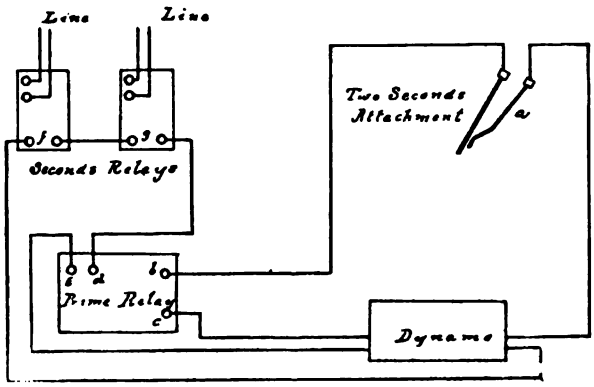
with one of the latter set. The wheel operating the second set revolves once in twenty-four hours and has three cams on it. One is so placed that it will close the springs from some time before and after seven o'clock in the morning; the second that it will close them before twelve, noon, and keep them closed till after one in the afternoon; and the third that it will keep contact for some time before and after six in the evening. The first set is closed hourly by a single cam acting for a short time before and after the hour. Now, as the circuit is not closed unless both sets of springs are in contact, the signal will be sent only at the hours desired. The circuits closed by the quarter-hour striking attachment and the special signal attachment do not act directly, but pass first through the points of a relay which are closed exactly at the minute by the minute attachment. This is done that any imperfection in the cutting or irregularity in the motion of the cam-wheels may not send the signals too soon or too late.

The various relays claim a short consideration before we proceed to describe the circuits and currents. In principle they are similar to the ordinary form of relay, but they differ somewhat in detail of construction. The difference, however, is unimportant. We shall have occasion in the following paragraphs to talk of the minute relay, the prime-seconds relay, the controlling relays, the striker relays and the local relays. The minute relay is controlled by the minute attachment of the clock. It is so constructed that when the current in the coils is broken by the minute attachment the points of the relay are closed. In the prime-seconds relay the points are closed at every action of the toothed minute-wheel on the spring of the two-seconds attachment. The closing of the points of this relay operates the controlling relays, which in turn close the circuit in the main lines. The striker relays are controlled by the striker clock, and independently of the controlling relays operate the main lines. The local relays are those placed with the subscribers along the main lines, and are the ones that indicate the time.

It now remains to explain in detail the various circuits which operate the striker clock and the different relays. For a clear conception of the system, each circuit will be considered separately; nor is it of importance that they should be shown in entirety, as the arrangement and connections of the various currents are more a matter of convenience than of necessity.

The two-seconds current, being the most important, demands our attention first. The diagram, Fig. 6, will aid in making the matter clear. Whenever the springs, a, are separated by a cam of the minute-wheel of the clock, that is, every two seconds, a circuit, running from the dynamo through the springs to the coils of the prime-seconds relay and back again to the dynamo, is broken.

FIG. 6.

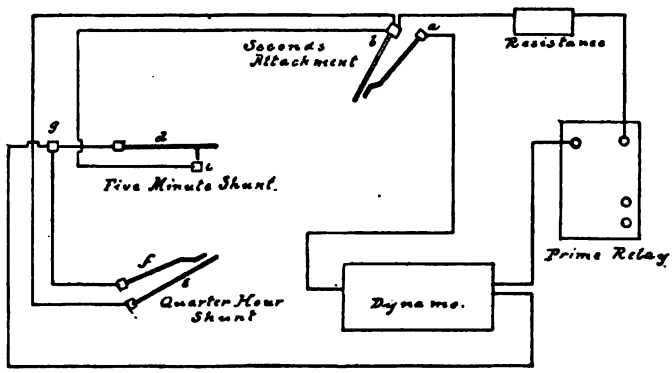


The release of the armature of the prime-seconds relay closes the points, d, e, of the relay and produces a second current, which flows from the dynamo through the points of the prime relay and through the coils of the controlling relays back to the dynamo. The closing of the points of the controlling relays by this last current completes the circuit in the main lines.

The two-seconds beats, it will be remembered, are not sent over the line continuously, but are omitted at certain definite times for longer or shorter periods, to serve as indications of the true time. Thus the fifty-eighth second's beat is omitted as an indication that the following beat is the beginning of a minute. Furthermore, the beats are omitted during the last twenty seconds of each five minutes, during forty-five seconds before and one minute after each quarter-hour, and for one and three-quarter minutes before and two minutes after the hour. The first of these omissions is accomplished, as already stated, by the omission of a cam on the wheel operating the two-seconds spring. The other blank intervals are the result of the action of the five-minute and the quarter-hour shunts. Their connections and mode of action are shown in Fig. 7. The wires from the two-seconds springs are connected at

the binding posts, a, b, with the wires to the two-seconds relay and dynamo. A wire from the shelf, c, of the five-minute shunt, and one from the lower spring, e, of the quarter-hour shunt connect with the binding post, b. The wires from the springs, d and f, go to the binding post, g, from which a wire goes to the dynamo. When neither of the shunts are in operation and the two-seconds springs are brought in contact, the current passes through the seconds relay. If, however, either c and d, or e and f, are in con-

FIG. 7.



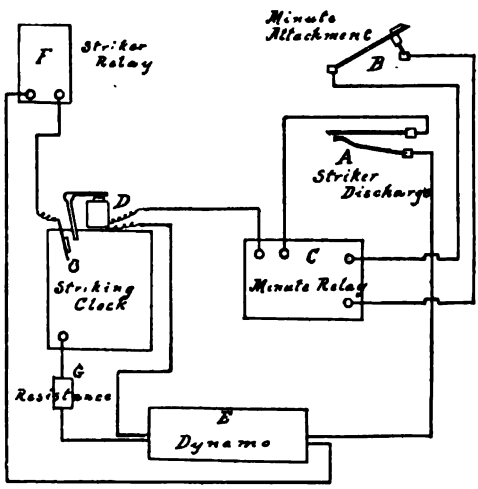
tact, the current will pass directly from b through them to g, and thence back to the dynamo. It is evident that some high resistance must be provided, else the current would pass quite as readily through the relay as through the shunts.

The wires from the one-minute attachment of the clock pass directly to the coils of the minute relay. However, there is inserted, on one of the wires, from the attachment to the coils, a resistance, the purpose of which will appear when we describe the circuit of the special signal.

We have just seen how, before and after every quarter-hour, the current operating the two-seconds relay is shunted off, and remember that at the quarter-hour the time is sent over the line by the striker; we shall now see how the latter is made to begin to strike at exactly the quarter-hour. The wires from the discharge A, Fig. 8, pass to the points of the minute relay, C, then to the coils of the quarter striker, from there to the dynamo and back again to the discharge. The spring and the cam-wheels of the striker clock, which are brought in contact as each tooth is lifted

by the gathering wheel, are connected through the dynamo with the coils of the striker relays. Contact is made in the discharge a few seconds before the time, but the current is still open at the points of the minute relay. When the spring of the minute attachment is lifted from the abutting screw, which happens about one second before the exact minute, the armature of the relay flies back and closes the circuit in the points. The current in the coils,

FIG. 8.

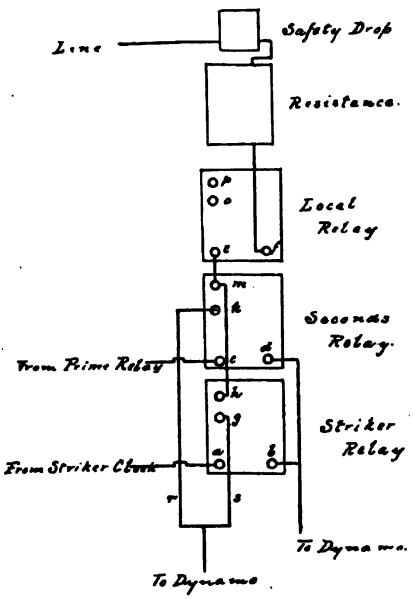


D, of the striker makes an electro-magnet, and the armature attracted thereby moves the main lever. This allows the sets of teeth to fall in their respective snails, where they remain until the release of the armature and the consequent return of the main lever start the train of the clock-work. At the exact minute the spring and abutting screw in the minute attachment are again brought in contact, and the resulting current in the magnet of the relay again draws up the armature and breaks the current flowing to the coils of the striker. The armature is thus released, the lever flies back and starts the clock-train, and the beats of the striker are sent through the striker relays and thence along the lines.

The connection between the striker relays and those that we have called the controlling or seconds relays is shown in Fig. 9. The lowest of the relays is the striker relay, the coils of which are connected with the striker clock; the middle relay is the con-

trolling relay which is governed by the prime-seconds relay, and the third is the local line relay, the object of which is to indicate whether the lines are in working order. The points k and g of the seconds and striker relays are connected with the dynamo from which a wire goes to the ground. The points m and h are connected with each other. From m a wire goes to e of the local relay and through the coils to f. From f a wire passes through a

FIG. 9.



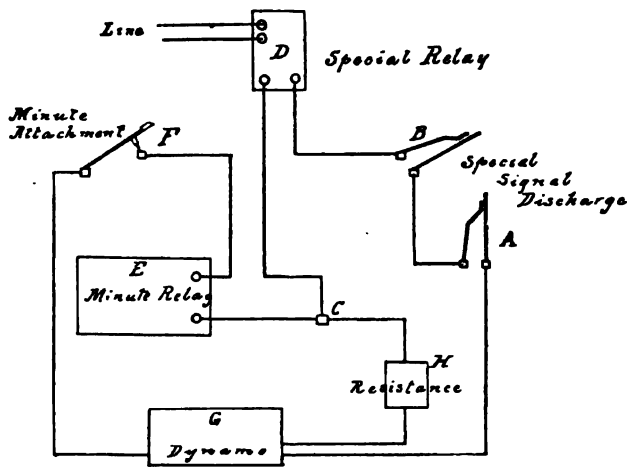
resistance coil to one pole of a safety drop, a mechanism by which the line may be cut off without disturbing any of the local circuits at the managing office. From the other pole of the safety drop runs the wire operating the relays of the subscribers or, in other words, the main line. At its other extremity it is run into the ground.

It may at first seem that the connection of the seconds and striker relays, as described, would interfere; but closer examination will show that as these relays are run independently and never simultaneously, the points of both will never be closed at the same time. Thus when the seconds relay is in operation and the points m and k are closed, the current will flow from the dy-

namo through the wire r to k and from m to e, and thence through the rest of the line. And when there is a circuit through the coils of the striker relays the points g and h are closed and the current flows from the dynamo through s to g, h, m, e and the remainder of the line.

The special signal, the blowing of a whistle at several hours in the day, is sent over a separate line. Contact is made in the discharge, A, Fig. 10, about the hours for the signal, and in B each hour. From B a wire passes through the coils of the special relay, D, to the binding post, C, thence through the coils of the

FIG. 10.



minute relay, E, to the minute attachment of the clock, F, and through the dynamo back to the discharge, A. A wire passing through a high resistance also connects the dynamo and the binding screw, C. If now, either of the discharges, A and B, are open, the minute current will flow directly from the dynamo to C, through the resistance, H, and the circuit will be complete. When, however, both discharges, A and B, are closed, and the minute attachment is closed, the current will flow through the discharges and the special relay. If we suppose that the discharge, A, is already closed and B is closed just after the spring at F has been raised from the abutting screw, the circuit will not be closed until the spring drops back against the screw, and the circuit will then be made exactly at the hour. The closing of the circuit in the special

relay causes the closing of the circuit in the line, and this, with the aid of a local relay and a local battery, may be made to blow the whistle automatically.

It will be understood, as a matter of course, that in practice the currents are not always as direct as shown in the diagrams; but that, for instance, where a number of wires pass to the same point as one pole of the dynamo, they may be gathered into one to some advantage. But this is a matter of expedience and convenience, and does not directly concern us.

In conclusion, let us review the indications by which we can tell what time it is. It is not intended that the service should act as a time-piece, but rather as an accurate supplement to one. The successive beats come at intervals of two seconds, beginning on the exact minute and continuing on 2, 4, 6, etc. The fifty-eighth second is omitted, so that the minute may be definitely determined. The beginning of every five minutes is marked by the omission of the last twenty seconds of the previous five minutes. The quarter-hour is preceded by a pause of forty-five seconds. At the quarter-hour the hour is struck by a corresponding number of beats, and one, two, or three double beats for the first quarter, half-hour and third quarter respectively. The beginning of the striking is the beginning of the quarter-hour, and after the striking there are no beats till the beginning of the next minute. At the hour the pause is one and three-quarter minutes before and two minutes after, and the hour is marked by a single beat. A general rule may be observed here that the first beat after any pause is the beginning of a minute.

Such, then, is the way in which accurate time may be and is distributed throughout a large district to a goodly number of subscribers.

AN ECONOMICAL METHOD OF PROSPECTING IN SOFT GROUND.

BY FERD. S. RUTTMANN.

It frequently happens that the mining engineer is called upon to conduct prospecting work; that is, to determine whether a certain indicated deposit of mineral is of sufficient value to justify

the undertaking of permanent mining operations as a probable profitable investment. The position of the ore-body may, or may not be known, but its extent and the quality of the ore is as yet questionable. It is, of course, to the advantage of both property-owner and engineer that these two essential elements be determined as fully as possible, in the most expeditious manner and with the least outlay of capital.

The manner in which such work has generally been conducted, has been by means of adits (where possible), shafts and drifts. This method is expensive in proportion to the nature of the ground in which the work is located. The value of the deposit being unknown, it may be inexpedient to make such a large outlay of capital in preliminary work, as the nature of the ground and the difficulties to be encountered would demand, especially as this outlay is liable to be a total loss, which is frequently the case. At the same time the engineer is unwilling to give his approval to inferior, more economical and more dangerous work.

In more recent years, the diamond drill has played an important part in prospecting for ore, nor is its value in such work yet fully appreciated. By its use, one may prove the extent and quality of a deposit almost as well as with a shaft and at one-fourth of the expense. The diamond drill is, however, inapplicable to soft ground, clays or gravel, in which many of our beds of Limonite, Manganese and Manganiferous iron ores occur.

Drifting and shafting in such ground being costly, until the value of the deposit is shown, it is advisable to use a more economical system, if possible.

The writer was recently called upon to conduct such prospect work as above outlined, and as a result adopted the plan which is given below.

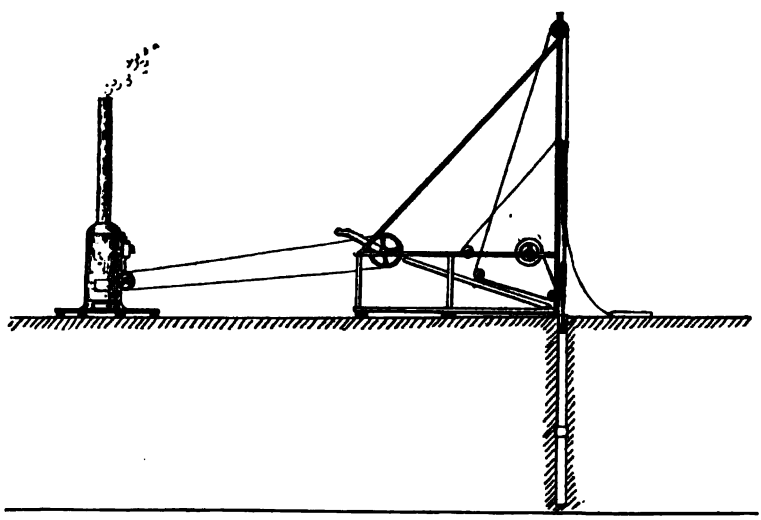
The immediate object of the search was a bed of Brown Hematite containing Manganese, which was known to exist in the vicinity. The character and quality of the float-ore found, gave promise of a valuable deposit could it be found. From the geological structure and the topography of the surrounding country the position in which this body of ore should be, was located within reasonable limits. The character of the ground was an alluvial deposit consisting of alternating strata of gravel, sand, clays and ochre.

The shaft was first started, but the amount of water entering,

soon proved that the expense of pumping and the heavy timbering required would hardly be warranted by the knowledge of the ore already gained. An adit was also started which would strike the supposed ore-bed at a depth of about seventy-five feet from the surface. The clay strata, however, on being exposed to the air and infiltration of water necessitated such expensive timbering that this also became a serious question from an economical point of view.

The plan of prospecting finally adopted was that of boring vertical holes with an artesian-well drilling machine. Such a machine was found, built upon the same principle as an oil-well drilling outfit, but on a smaller scale, capable of drilling to a depth of 250 to 300 feet.

In this machine the high derrick is replaced by a stayed mast 30 feet in height, at the top of which is a grooved pulley or sheave,



over which passes the cable to which are attached the tools. The tools consist of an auger stem, jars and drill proper, in all respects similar to those for deep wells, the weight, however, being proportioned to the size of the machine and the limited depth.

Instead of a walking beam, the tools are lifted by a cam (which is keyed upon the main driving-shaft) striking a lever to which is attached a pulley through which passes the cable; another pulley

placed near the fulcrum of the lever diminishes the wear of the cable to a minimum. The accompanying outline sketch shows this part of the machine.

A sand reel, line and pump are provided, the reel being worked by a friction belt connected with a pulley on the main shaft. Suitable gear for raising and lowering the tools is attached to the machine. The whole can be taken apart easily so that the heaviest part may be carried by two men—thus being easily conveyed from place to place as occasion requires; finally the machine is easily driven by a four horse-power engine.

The machine being placed in position and the tools attached, the drill hole is started by allowing the tools to drop and strike against the ground, care being taken to keep the hole vertical. The drop is either 10 or 14 inches as desired. When two or three feet in depth have thus been drilled, the tools are raised, the sand-pump is brought into requisition and the hole emptied of its mixture of churned up clay and water.

After repeating this operation until a depth of 10 or 12 feet has been obtained, it is well, if the ground be soft, to put in the well casing. This consists of heavy iron pipe provided on the lower end with an annular steel shoe with a sharp cutting edge. A heavy drive cap is screwed upon the upper end, upon which the maul or pipe driver descends. This maul is merely a log of wood 8 or 10 feet long and 12 inches in diameter, attached to the cable and dropped by the same means as the drill. Having driven the length of pipe down, the cap is taken off and drilling resumed through the pipe, the drill being small enough to pass through the pipe. The difference between the hole bored by the drill and the outside diameter of the pipe being cut down by the shoe and raised to the surface.

By means of the sand-pump, samples of all the strata can be brought up for examination or assay, the condition of the material varying from slimes to pieces an inch or so in diameter, amply sufficient to detect the character of all the material through which the drill passes. Upon reaching the ore body or rock the casing need not be continued further, as there is slight danger of the sides of the hole caving in.

The cost of a machine and engine adapted to the work above described is about $800 to $900, including drive-pipe 6 inches in

diameter. It is easily managed by two men, though in a rough country, it is advisable to have an additional man to cut fuel, assist in changing tools, etc. From 10 to 40 feet per day can be driven through sand or clay. A depth of 80 feet has been obtained in a 10-hour shift, though this is unusual. The cost of drilling varies from 50 cents to $2.00 per foot, according to the nature of the ground. This cost does not include the cost of the pipe, but as this may be drawn up and used again, the added cost per foot is small. In cases where the quality of the ore proves it of little value, this method proves the fact at a small expense. Where the deposit is proved of value, the additional expense is a small factor in the general cost and is often overbalanced by the information obtained, which is of great importance in planning permanent operations.

When it is considered that much of the geological structure of Western Pennsylvania has been determined by the material brought up from oil-wells by the sand-pump, the value of this method of prospecting may be better realized.

AN ELECTRIC TABULATING SYSTEM.

BY H. HOLLERITH.

FEW, who have not come directly in contact with a census office, can form any adequate idea of the labor involved in the compilation of a census of 50,000,000 persons, as was the case in the last census, or of over 62,000,000, as will be the case in the census to be taken in June, 1890. The fact, however, that Congress at its last session in "An Act to provide for the taking of the eleventh and subsequent censuses," fixes the maximum cost of the next or eleventh census, exclusive of printing and engraving, at $6,400,000, will perhaps impress one with some idea of the magnitude of such an undertaking.

Although our population is constantly increasing, and although at each census more complicated combinations and greater detail are required in the various compilations, still, up to the present time, substantially the original method of compilation has been

employed; that of making tally-marks in small squares and then adding and counting such tally-marks.

While engaged in work upon the tenth census, the writer's attention was called to the methods employed in the tabulation of population statistics and the enormous expense involved. These methods were at the time described as "barbarous," and the suggestion was made that some machine ought to be devised for the purpose of facilitating such tabulations. This led the writer to a thorough study of the details of the methods used, which were no doubt the most approved ever employed in compiling a census. After a careful consideration of the many problems involved and considerable experimenting on quite a large scale, the method which forms the subject of this paper is confidently offered as a means for facilitating this work.

The work of a census can be divided into two main branches: that of enumeration, and that of compilation or tabulation. In regard to the enumeration, the plan originally adopted at the tenth census, with such splendid results, will substantially be followed in the next census, and is provided for in the Act of Congress above referred to. As under the provisions of this Act the enumerators are paid according to the number of persons, farms, or manufacturing establishments enumerated, and as the rates of compensation are slightly increased, the per capita cost of the enumeration must of necessity be slightly in excess of that of the tenth census. Referring to the records of the tenth census, we find the cost of the enumeration to have been $2,095,563.32.*

An increase of population of thirty per cent. during the decade can reasonably be assumed, so that the cost of the enumeration at the eleventh census, at the same per capita rate, would be not less than $2,724,232.32. Adding to this amount the cost of the extra schedules required under the present Act of Congress and allowing for the increased rates of compensation for the enumer-

* The cost of the tenth census was as follows:

Enumerators,	$2,095,563.32
Superintendent's Office,	2 385,999.50
Special Agents,	625,067.29
Printing Reports,	678,624.61
Total,	$5,785,254.72

ation of farms and manufacturing establishments,* we see that an estimate of $3,000,000 is not an unreasonable one for the cost of the next enumeration.

From the data thus enumerated are compiled the various reports which form the legitimate work of a census. The expenses of the office of the Superintendent of the Tenth Census at Washington amounted to $2,385,999.50. If the same methods of compilation are to be employed in the next census, the per capita cost of compilation would, of course, remain substantially the same, so that allowing for the increased population, the expenses of this portion of the work would amount to $3,101,799.67. To this ought also be added the cost of compiling the additional data required under the present Act of Congress. If, however, the data enumerated at the next census is compiled with that fulness and completeness which it deserves, and which it ought to receive, these expenses would far exceed the above amount. As will be shown presently, many of the facts enumerated in the tenth census were not compiled at all, or if compiled were treated in so simple and elementary a manner as to leave much to be desired. On the other hand, however, the compilations of the tenth census were so vastly superior to anything that had previously been attempted that it is very likely to be inferred that the tenth census left nothing to be desired. If at the eleventh census no material improvements are adopted in the methods of tabulation, it will probably be found impossible to accomplish more than at the tenth census on account of the time and expense involved.

A census is often spoken of as a photograph of the social and economic conditions of a people. The analogy can be made, not only with reference to the results obtained, but also to the methods

*

Enumerators.	Rates of Compensation.	
	1890. Cents.	1880. Cents.
For each inhabitant enumerated, ...	2	2
For each death recorded, ...	2	2
For each farm returned, ...	15	10
For each manufacturing industry reported, ...	20	15
For each soldier, sailor, etc., ...	5	.....

of obtaining these results. Thus the enumeration of a census corresponds with the exposure of the plate in photography, while the compilation of a census corresponds with the development of the photographic plate. Unless the photographic plate is properly exposed it is impossible to obtain a good picture, so likewise, in case of a census, a good result is impossible unless the enumeration is made properly and with sufficient detail. As the first flow of the developer brings out the prominent points of our photographic picture, so in the case of a census the first tabulations will show the main features of our population. As the development is continued, a multitude of detail appears in every part, while at the same time the prominent features are strengthened, and sharpened in definition, giving finally a picture full of life and vigor. Such would be the result of a properly compiled and digested census from a thorough enumeration. If this country is to expend $3,000,000 on the exposure of the plate, ought not the picture be properly developed?

The population schedules of the tenth census contained the following inquiries, the replies to which were capable of statistical treatment:

Race or color: whether white, black, mulatto, Chinese, or Indian.

Sex.

Age.

Relationship of each person enumerated to the head of the family.

Civil or conjugal condition: whether single, married, widowed, or divorced.

Whether married during the census year.

Occupation.

Number of months unemployed.

Whether sick or otherwise temporarily disabled so as to be unable to attend to ordinary business or duties on the day of the enumeration; what was the sickness or disability?

Whether blind, deaf and dumb, idiotic, insane, maimed, crippled, bedridden, or otherwise disabled.

Whether the person attended school during the census year.

Cannot read.

Cannot write.

Place of birth.

Place of birth of father.

Place of birth of mother.

Such an enumeration as this, if made thoroughly, certainly corresponds to a fully timed exposure of our photographic plate. It would scarcely be termed under-exposed.

If it is of interest and value to know the number of males and of females in our population, of how much greater interest is it to know the number of native males and of foreign males; or again, to know the number of native white males, of foreign white males, of colored males, etc.; or still again, the combination of each one of these facts with each single year of age. All this was done in the tenth census. Many other interesting and valuable combinations were compiled, far surpassing anything of the kind that had ever before been attempted, still, on the other hand, many of the facts enumerated were never compiled at all. Thus, for example, it is to-day impossible to obtain the slightest reliable statistical information regarding the conjugal conditions of our people, though the complete data regarding this is locked up in the returns of the enumeration of the tenth census. In other words, the development was not carried far enough to bring out even this most important detail of our picture. The question why this information was not compiled was several times asked during the discussion of the present census bill in the committee of the Senate. A correct and proper answer to this inquiry would probably have been simply, "lack of funds." It certainly cannot be considered for a minute that the eminent statistician who planned and directed the tenth census did not fully appreciate the value of such a compilation.

To know simply the number of single, married, widowed, and divorced persons among our people would be of great value, still it would be of very much greater value to have the same information in combination with age, with sex, with race, with nativity, with occupation, or with various sub-combinations of these data.

If the data regarding the relationship of each person to the head of the family were properly compiled, in combination with various other data, a vast amount of valuable information would be obtained. So again, if the number of months unemployed were properly enumerated and compiled with reference to age, to occupation, etc., much information might be obtained of great

value to the student of the economic problems affecting our wage-earners.

One more illustration will be given. We have in a census, besides the data relating to our living population, records regarding the deaths during the previous year. In both cases we have the information regarding age and occupation. If the living population were tabulated by combinations of age and occupation, and likewise the deaths by ages and occupations, we would then have data from which some reliable inferences might be drawn regarding the effects of various occupations upon length of life. It might even be possible to construct life tables for the various occupations as we now do for the different States and cities. Such information would be of service in relation to life insurance and other problems. Again, it would point out any needed reforms regarding the sanitary conditions and surroundings of any occupation. This is a field of statistical investigation which is as yet almost wholly unexplored.

In this connection it may perhaps be proper to quote from a letter addressed to the writer, in reply to certain inquiries, by General Francis A. Walker, the well-known Superintendent of the Tenth Census:

"In the census of a country so populous as the United States the work of tabulation might be carried on almost literally without limit, and yet not cease to obtain new facts and combinations of facts of political, social, and economic significance.

"With such a field before the statistician, it is purely a question of time and money where he shall stop. Generally speaking, he cannot do less than has been done before in the treatment of the same subject. Generally speaking, also, he will desire to go somewhat beyond his predecessors, and introduce some new features to interest and instruct his own constituency, so that there is a constant tendency to make the statistical treatment of similar material successively more and more complex. It will even frequently happen that these later refinements in the statistics of a country are of greater economic significance than some of the earlier and more elementary grouping of facts."

No one is more competent to speak authoritatively on this question than General Walker, and certainly no one's opinion is more worthy of consideration.

Irrespective of the wishes and desires of those who are in charge

of our various statistical inquiries, we often find in this country that public opinion needs and demands certain statistical information. Thus in the present Act of Congress while the main points are left discretionary with the Secretary of the Interior, under whose direction the census is taken, still on certain points direct instructions are given. For example, it is provided that the colored population be enumerated and tabulated with reference to the distinctions of blacks, mulattoes, quadroons, and octoroons. In the census of 1860 the population was compiled under 14 age groups, in 1870 the ages were tallied under 25 groups, while in 1880 the census office, in compliance with numerous requests from many different sources, tabulated the population according to single years of age, making in all over 100 specifications. Thus we see that each year the problem of compiling a census becomes a more difficult one.

Heretofore in census and similar compilations essentially one of two methods has been followed. Either the records have been preserved in their proper relations, and the information drawn off by tallying first one grouping of facts and then the next, or the records have been written upon cards or slips, which are first sorted and counted according to one grouping of facts and then according to the next.

To form some idea of the questions involved in the first plan, let us assume that the record relating to each person at the next census be written in a line across a strip of paper, and that such lines are exactly one-half inch apart, it would then take a strip of paper over 500 miles long to contain such records. These must be gone over, again and again, until all the desired combinations have been obtained. This is practically the method followed in compiling the tenth census. On the other hand, if written cards are to be used the prospect is hardly more encouraging. One hundred comparatively thin cards will form a stack over an inch high. In the next census, therefore, if such cards are to be used it will require a stack over ten miles high. Imagine for a moment the trouble and confusion which would be caused by a few such cards becoming misplaced. This method of individual cards was employed in the census of Massachusetts for 1885. The 2,000,000 cards there used weighed about 14 tons. Were the same cards to be used in the next United States census it would require about 450 tons of such cards.

In place of these methods it is suggested that the work be done so far as possible by mechanical means. In order to accomplish this the records must be put in such shape that a machine could read them. This is most readily done by punching holes in cards or strips of paper, which perforations can then be used to control circuits through electro-magnets operating counters, or sorting mechanism, or both combined.

Record-cards of suitable size are used, the surfaces of which are divided into quarter-inch squares, each square being assigned a particular value or designation. If, for example, a record of sex is to be made, two squares, designated respectively M and F, are used, and, according as the record relates to a male or a female, the corresponding square is punched. These holes may be punched with any ordinary ticket-punch, cutting a round hole, about three-sixteenths of an inch in diameter. In similar manner other data, such as relate to conjugal condition, to illiteracy, etc., is recorded. It is often found, however, that the data must be recorded with such detail of specification that it would be impracticable to use a separate space for each specification. In such cases recourse is had to combinations of two or more holes to designate each specification. For example, if it is desired to record each single year of age, twenty spaces are used, divided into two sets of ten each, designated, respectively, from 0 to 9. One set of ten spaces is used to record the tens of years of age, while the other set is used to record the units of years of age. Thus, twelve years would be recorded by punching 1 in the first set, and 2 in the second; while 21 years would be recorded by punching 2 in the first set, and 1 in the second set. Occupations may be arranged into arbitrary groups, each such group being designated, for example, by a capital letter, and each specific occupation of that group by a small letter. Thus, Aa would designate one occupation, Ab another, etc. If desired, combinations of two or more letters of the same set may be used. Thus, AB can be used to designate one occupation, AC another, BC another, etc. With such an arrangement, the initial letter may be used to designate groups of occupation as before. In this way it is apparent that a very small card will suffice for an elaborate record. For the work of a census, a card 3″ x 5½″ would be sufficient to answer all ordinary purposes. The cards are preferably made of as thin manilla stock as will be convenient to handle.

If printed cards are used, the punching may be done with ordi-

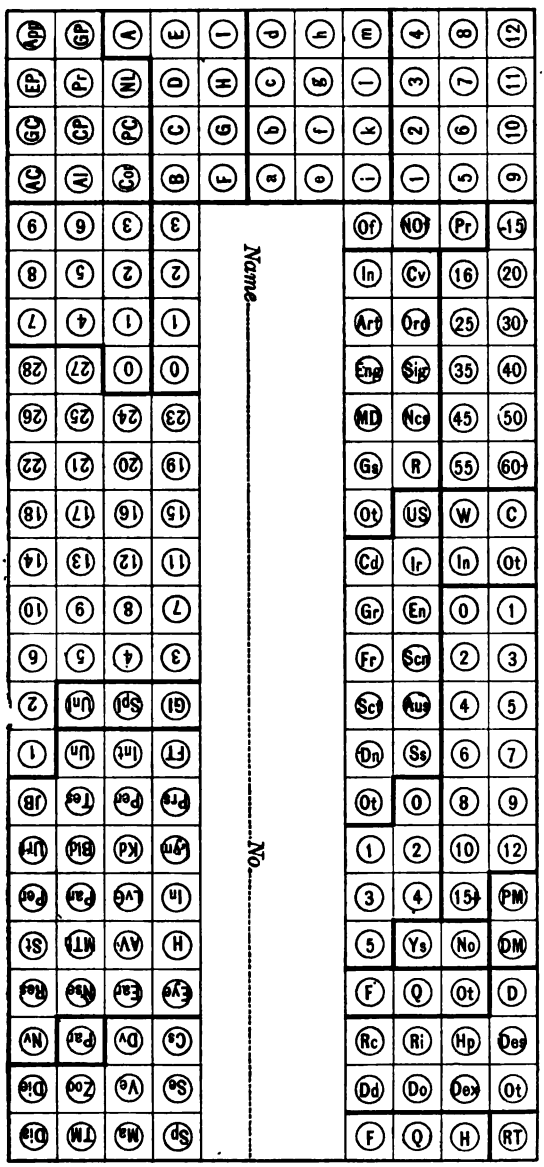
nary ticket-punches; more satisfactory results, however, can be obtained with punches designed especially for this work, as will be presently described.

In a census the enumerator's district forms the statistical unit of area, and a suitable combination is arranged to designate each such district. A card is punched with the corresponding combination for each person in such enumeration districts, and the cards of each district are then numbered consecutively, in a suitable numbering machine, to correspond with numbers assigned to the individual records on the enumerator's returns. This combination of holes, and this number, will serve to identify any card. Should any card become misplaced, it is readily detected among a number of cards by the fact that one or more of these holes will not correspond with the holes in the balance of the cards. By means of a suitable wire or needle a stack of a thousand or more cards can be tested in a few seconds, and any misplaced cards detected When it is remembered that in a census millions of cards must constantly be handled, the importance of this consideration is appreciated. With ordinary written cards it would be practically impossible to detect misplaced cards, and a few such misplaced cards would cause almost endless confusion.

As the combination of holes used for designating the enumerator's district are the same for all the cards of that district, a special machine is arranged for punching these holes. This machine is provided with a number of interchangeable punches, which are placed according to the combination it is desired to punch. Five or six cards are then placed in the punch against suitable stops, and by means of a lever the corresponding holes are punched through these cards at one operation.

The individual records are now transcribed to the corresponding cards by punching according to a pre-arranged scheme as described above. For this purpose what may be known as a keyboard-punch is arranged, in which the card is held fixed in a frame, while the punch is moved over the card in any direction by means of a projecting lever provided with a suitable knob or handle. Below the knob is a keyboard provided with holes lettered and numbered according to the diagram of the card, and so arranged that when a pin projecting below the knob is over any hole, the punch is over the corresponding space of the card. If the pin is depressed into any hole of the keyboard, the punch is operated and the corre-

sponding space of the card is punched. With such a keyboard-punch it is, of course, apparent that a perfectly blank card may be



Card Used in Surgeon-General's Office.

FIG. 1.

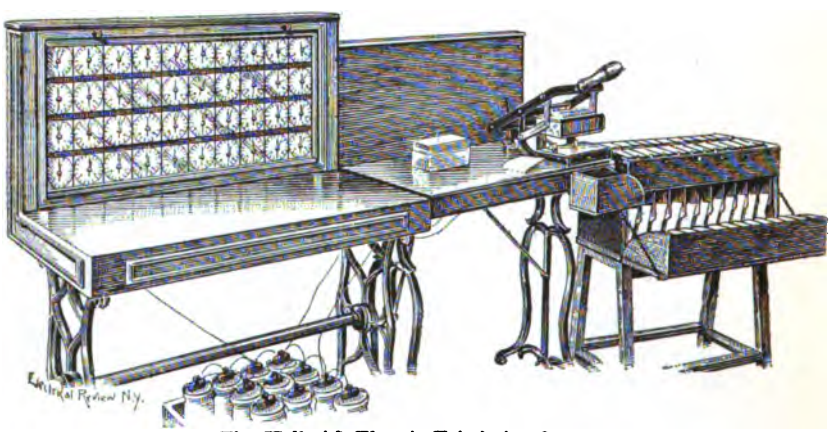
used, one corner, however, being cut off to properly locate the card in subsequent operations.

To read such a punched record card, it is only necessary to

place it over a printed form, preferably of a different color, when the complete record shows directly through the perforations.

Heretofore, reference has only been made to the compilation of a census, but these methods are equally applicable to many other forms of statistical compilations, as, for example, the various forms of vital statistics. Fig. 1, for example, represents the diagram of the card as at present used in the office of the Surgeon-General U.S.A., for compiling the army health statistics. The data relating to the month, the post, the division, and the region to which the record relates, is recorded by punching a hole in each of the divisions across the end of the card by means of the machine with interchangeable punches as before described. This portion of the

FIG. 2.



The Hollerith Electric Tabulating System.

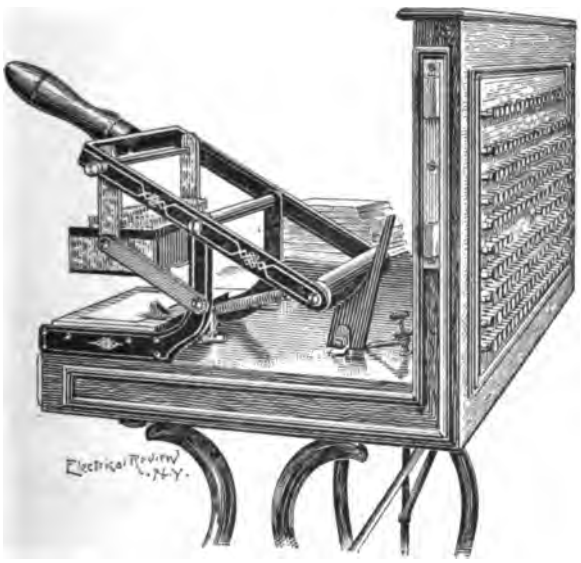
record corresponds almost exactly with the record for the enumeration district of a census. The individual record is then transcribed to the card by punching in the remaining spaces with a keyboard-punch as before described.

Such a card allows a complete record, including the following data, for each individual; rank, arm of service, age, race, nationality, length of service, length of residence at the particular post, whether the disease was contracted in the line of duty or not, whether admitted to sick report during the month or during a previous month, the source of admission, the disposition of the case, or whether remaining under treatment, the place of treatment, the disease or injury for which treated, and finally the number of days treated. Between 40,000 and 50,000 such records are received

annually, and from these are compiled the various health statistics pertaining to our army.

A card has just been arranged for the Board of Health of New York City to be used in compiling the mortality statistics of that city. The record for each death occurring in the City of New York, as obtained from the physicians' certificates, is transcribed to such a card by punching as before described. This card allows for recording the following data: sex, age, race, conjugal condition,

FIG. 3.



The Press.

occupation, birthplace, birthplace of parents, length of residence in the city, the ward in which the death occurred, the sanitary subdivision of such ward, the nature of the residence in which the death occurred, whether a tenement, dwelling, hotel, public institution, etc., and finally the cause of death. In the city of New York about 40,000 deaths are recorded annually.

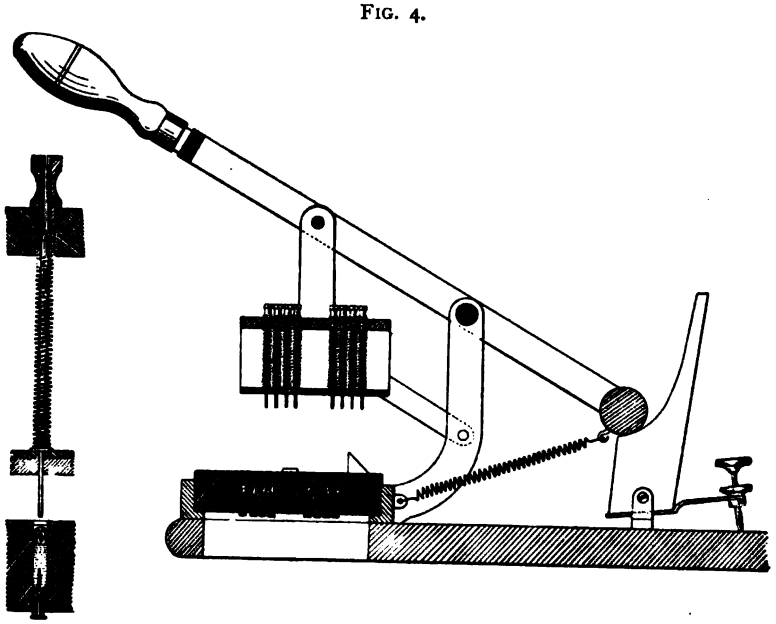
These illustrations will serve to show how readily a card can be arranged to record almost any desired grouping of facts.

With a little practice great expertness is secured in making such transcriptions, and a record can thus be transcribed much more readily than by writing, even if considerable provision is made for facilitating the writing by the use of abbreviations.

From the punched record cards it next becomes necessary to

compile the desired statistics. For this purpose the apparatus shown in Figs. 2 to 8 is used. The press or circuit-closing device, shown in Figs. 2, 3, and 4, consists of a hard rubber bed plate, as shown in section in Fig. 4, provided with suitable stops or gauges against which the record-cards can be placed. This hard rubber plate is provided with a number of holes or cups corresponding in number and relative position with the centres of the

FIG. 4.



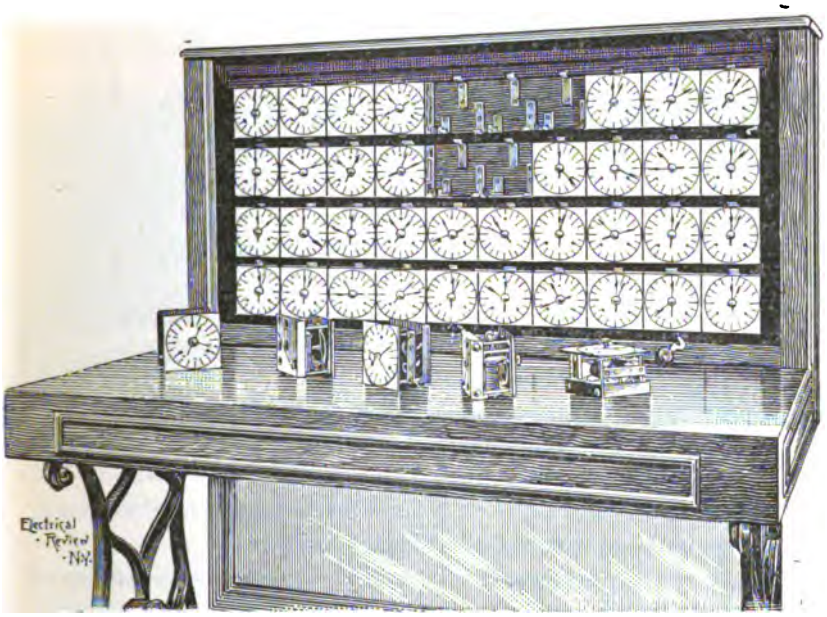
Sections of Pin and Press.

spaces of the card. An iron wire nail is securely driven through a hole in the bottom of each cup, and a wire, connecting at its other end with a binding-post on the back of the press frame, is securely held under the head of each nail. Each cup is partly filled with mercury, which, through the nail and wire, is thus in electrical connection with the corresponding binding-post. Above the hard rubber plate is a reciprocating box provided with a number of projecting spring-actuated points, corresponding in number and arrangement with the centres of the mercury cups. The construction and arrangement of these pins is shown in Fig. 4. If a card is placed on the rubber plate against the stops it is of course apparent that, when the box is brought down by the handle, the pins will all be pressed back, excepting such as corre-

spond with the punched spaces of the card which project into the mercury, and are thus in electrical connection with the corresponding binding-posts on back of the press frame.

A number of mechanical counters are arranged in a suitable frame, as show in Fig. 5. The face of each counter is three inches square, and is provided with a dial divided into 100 parts and two hands, one counting units the other hundreds. The counter consists essentially of an electro-magnet, the armature of which is so arranged that each time it is attracted by closing the

FIG. 5.



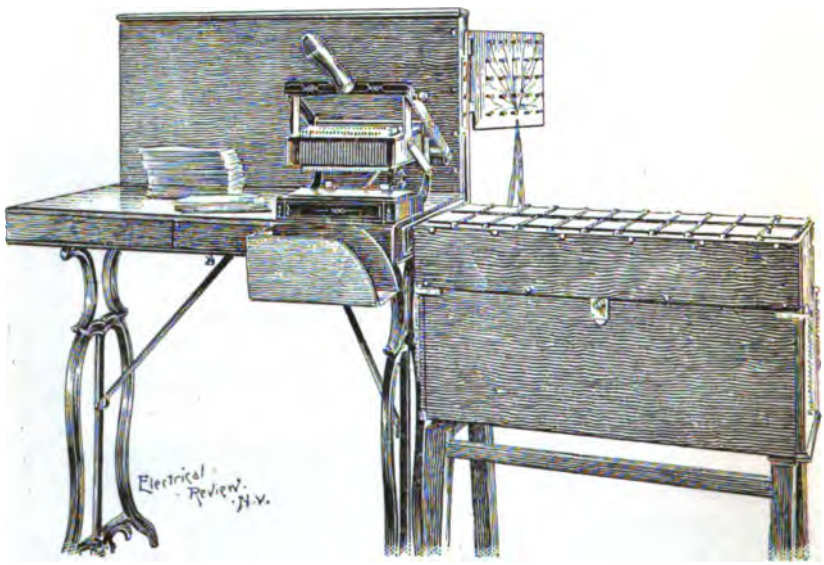
The Counters.

circuit it registers one. A suitable carrying device is arranged so that at each complete revolution of the unit hand the hundred hand registers one, each counter thus registering or counting to one hundred hundred, or 10,000, which will be found sufficient for all ordinary statistical purposes. The counters are so arranged that they can readily be reset at 0, and all are removable and interchangeable, the mere placing of the counter in position in the frame making the necessary electrical connections through the magnet.

For the purpose of sorting the cards according to any group of

statistical items or combinations of two or more of such items, the sorting-box, shown in Fig. 6, is used. This consists of a box suitably divided into compartments, each one of which is closed by a lid. Each lid, L, as shown in Fig. 7, is held closed against the tension of the spring, S, by the catch, *a*, in the armature, A. If a circuit is closed through the magnet, E, the armature, A, is

FIG. 6.



The Sorting-box.

attracted, thus releasing the lid, L, which is opened by the springs, and remains open until again closed by hand.

As the cards are punched they are arranged by enumerators' districts, which form our unit of area. The first compilation that would be desired would be to obtain the statistics for each enumeration district according to some few condensed groupings of facts. Thus it might be desired to know the number of males and of females, of native born and of foreign born, of whites and of colored, of single, married, and widowed, the number at each of centre groups of ages, etc., in each enumeration district. In order to obtain such statistics the corresponding binding-posts on the back of the press frame are connected, by means of suitable pieces of covered wire, with the binding-posts of the counters upon which it is desired to register the corresponding facts. A proper battery being arranged in circuit, it is apparent that if a card is placed on

the hard rubber bed plate, and the box of the press brought down upon the card, the pins corresponding with the punched spaces will close the circuit through the magnets of the corresponding counters which thus register one each. If the counters are first set at 0, and the cards of the given enumeration district then passed through the press one by one, the number of males and of females, of whites and of colored, etc., will be indicated on the corresponding counters.

FIG. 7.

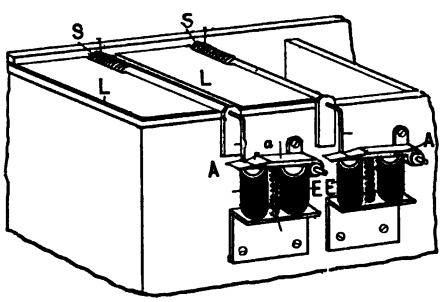


Diagram of Sorting-box.

If it is desired to count on the counters directly, combinations of two or more items, small relays are used to control secondary circuits through the counters. If, for example, it is desired to know the number of native white males, of native white females, of foreign white males, of foreign white females, of colored males, and of colored females; these being combinations of sex, race, and nativity, ordinary relays are arranged as shown in the diagram, Fig. 8, the magnets of which are connected with the press as indicated. If a card punched for native white, and male is placed in the press, the corresponding relays are actuated, which close a secondary circuit through the counter magnet, native white male, thus registering one on the corresponding counter.

By a suitable arrangement of relays any possible combination of the data recorded on the cards may be counted. When it is desired to count more complicated combinations, however, special relays with multiple contact points are employed.

If it is desired to assort or distribute the cards according to any desired item or combination of items recorded on the card, it is only necessary to connect the magnets of the sorting-box in exactly the same manner as has been described for the counters. When a card is then placed in the press, one of the lids of the sorting-box, according to the data recorded on the card, will open. The

card is deposited in the open compartment of the sorting-box and the lid closed with the right hand, while at the same time the next card is placed in position in the press with the left hand.

It is, of course, apparent that any number of items or combinations of items can be counted. The number of such items or combinations, which can be counted at any one time, being limited only by the number of counters, while at the same time the cards are sorted according to any desired set of statistical facts.

In a census the cards as they come from the punching machines would, of course, be arranged according to enumeration districts.

FIG. 8.

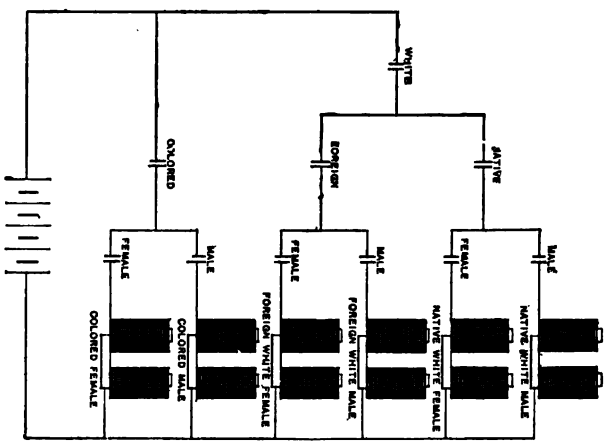


Diagram for Combination Counting.

Each districts could then be run through the press, and such facts as it is desired to know in relation to this unit of area could be counted on the counters, while the cards are at the same time assorted according to some other set of facts, arranging them in convenient form for further tabulations. In this manner, by the arrangement of a judicious "scheme," it will be found that a most elaborate compilation may be effected with but a few handlings of the cards.

Two of the most important elements, in almost all statistical compilations, are "time" and "accuracy." The rapidity with which results could be obtained with the present method, in a census, for example, would be dependent upon: 1st, the rate at which a clerk could punch the record-cards, and, 2d, the number of clerks employed upon this part of the work. The first can readily be determined by experiment, when the second becomes merely

a simple arithmetical computation. The work of counting or tabulating on the machines can be so arranged that, within a few hours after the last card is punched, the first set of tables, including condensed grouping of all the leading statistical facts, would be complete. The rapidity with which subsequent tables could be published would depend merely upon the number of machines employed.

In regard to accuracy, it is apparent that the processes of counting and sorting, being purely mechanical, can be arranged, with such checks, that an error is practically impossible. The one possible source of error is in the punching of the cards. If proper precautions are here taken, a census practically free from errors of compilation could be obtained. Even in this respect the present method would have manifest advantages. A card wrongly punched could involve an error of only a single unit, while by all previous methods single errors involving an error in the result of tens, of hundreds, of thousands, or even more, are possible.

It is firmly believed that in regard to cost, time and accuracy, this method would possess very great advantages in doing the work that has heretofore been done, but this is believed to be insignificant in comparison with the fact that a thorough compilation would be possible, within reasonable limits of cost, while such compilation is practically impossible, by the ordinary methods, on account of the enormous expense involved.

A SCHEME

FOR THE SEPARATION AND DETECTION OF AL, CR, FE, CO, NI, MN, ZN, BA, CA, SR, MG, IN THE PRESENCE OF PHOSPHORIC, ARSENIC, OXALIC, BORIC, SILICIC, HYDROFLUORIC, ACETIC, TARTARIC ACIDS AND ORGANIC MATTER.

BY J. S. C. WELLS, PH.D., AND H. T. VULTÉ, PH.D.

IT is a well known fact that the usual separation with ammonium hydrate, chloride and sulphide fail in the presence of any of the above-mentioned acids. The various methods in use are long and in most cases inaccurate. In presenting the following, we have tried to cover every point of importance, and wherever possible have used quantitative methods for the sake of accuracy.

The scheme has been given a careful trial and seems to meet all requirements.

If a solution containing the before-mentioned acids and bases is made alkaline with ammonium hydrate, the following is likely to occur:

H_3PO_4	ppts.	Al	Cr	Fe(ic)	Co	Ni	Mn	Zn	Ba	Sr	Ca	Mg
H_3BO_3	"	"	"	"	"	"	"	"	"	"	"	"
H_2SiO_3	"	"	"	"	"	"	"	"	"	"	"	"
H F	"	"	"	"	"	"	"	"	"	"	"	"
$H_2C_2O_4$	"	chiefly							"	"	"	"
H_3 As O_4	"	Fe(ic) and Mg										
$H_2C_4H_4O_6$	} prevent precipitation of Al, Cr, Fe, if boiling and neutral, $HC_2H_3O_2$ throws down Al, Cr and Fe as Basic Acetates.											
$HC_2H_3O_2$												
Organic Matter												

To test for the presence of these compounds three small portions of the main solution are taken, as follows:

Part I. Add HNO_3 and $(NH_4)_2$ Mo O_4 a yellow cryst. ppt. indicates phosphates, if heated gently a yellow color or ppt. indicates silicates and arsenates.

Part II. Add $H_2C_4H_4O_6$ and NH_4O H in excess a gelatinous ppt. indicates phosphates, borates, etc.

Part III. Add conc. H_2SO_4 and evaporate to dryness, a carbonaceous residue indicates organic acids or matter.

All the acids mentioned, except phosphoric, boric and arsenic, may be removed by evaporation with HNO_3 and ignition. Borates are soluble in a considerable excess of ammonium chloride and give no trouble.

Arsenates are removed by reduction with SO_2 and precipitation as As_2S_3 by H_2S. This should be done before adding HNO_3.

After making these tests, return to main solution.

Boil out H_2S. Add a few drops HNO_3 (Note 1). If $H_2C_2O_4$ or organic matter is present evaporate to dryness and ignite gently. If not, evaporate, but do not ignite. Treat residue with HCl (conc.), dilute with H_2O and boil; it dissolves wholly or leaves a white residue of SiO_2. Filter. To filtrate add NH_4Cl and NH_4OH in slight excess, heat gently and filter quickly, wash ppt. A with hot water. To filtrate add $(NH_4)_2$ S slight xs heat, filter and wash ppt. B. Examine filtrate for the alkalies and alkaline earths. Transfer ppts. A and B to a porcelain dish and digest with a little $(NH_4)_2$ S. (Note 2), filter and wash with H_2O and $(NH_4)_2$ S.

Filt. $(NH_4)_3PO_4$ $(NH_4)_2S$ Reject

Residue $Al_2(OH)_6$ $Cr_2(OH)_6$ FeS, $Al_2(PO_4)_2$ $Cr_2(PO_4)_2$ $Ba_3(PO_4)_2$ $Sr_3(PO_4)_2$ $Ca_3(PO_4)_2$ NH_4MgPO_4, MnS, ZnS, CoS, NiS, S.
Treat with cold very dilute HCl sp. gr. 1.05, filter and wash.

Residue
NiS + CoS + S
Test a portion in Borax Bead
Blue = Co
Brown = Ni
If blue, diss. in Cl evap. to expel xs acids & Cl, dil. + H_2O nearly neutralize + KOH add KCY until ppt. formed is diss., boil for 4 or 5 minutes, cool, add large xs KOH + Br water
a black ppt. $Ni_2(OH)_6$ wash with very dilute NH_4OH to remove last trace of Co test in Borax bead.
Brown Bead Ni

Filtrate
Contains Fe, Al, Cr, Zn + Mn as chlorides, and Al, Cr, Ba, Sr, Ca, Mg as Phosphates.
Boil out H_2S, dilute and make alkaline with Na_2CO_3, add Bromine water and boil until Cr is all oxidized and Br. removed. Filter.

Filtrate
Na_2CrO_4
Acidify with HĀ.
Test for Cr with $BaCl_2$ yellow ppt $BaCrO_4$ = Cr. (Note 3.)

Ppt $Al_2(OH)_6$ $Al_2(PO_4)_2$ $Fe_2(OH)_6$ $Fe_2(PO_4)_2$ Ba, Sr, Ca, Mg Phos. Zn + Mn Basic Carbs.. Diss. in least possible quantity of dil. HCl and add Fe_2Cl_6 until a few drops of the sol. give a yellow or red ppt. with NH_4OH. (Note 4.) Nearly neutralize with Na_2CO_3, dilute and add xs of Na Ā. Boil and filter hot. Wash ppt. with boiling H_2O.

Ppt.
Fe and Al as Phosphates and Basic Acetates add KOH and boil.

Ppt.
$Fe_2(OH)_6$
$Fe_2(PO_4)_2$

Filt.
Add HCl to acid reaction and then make alk. with $(NH_4)_2CO_3$ white ppt. $Al_2(OH)_6$ and $Al_2(PO_4)_2$.

Filtrate ‖.
Zn Mn Ba Sr Ca Mg as acetates or chlorides add NH_4Cl NH_4OH + $(NH_4)_2S$. Filter and wash.

Ppt.
ZnS + MnS.

Treat with HĀ.

Res
ZnS
Treat on charcoal with $Co(NO_3)_2$ green mass Zn.

Solution
$MnĀ_2$ add KOH white ppt. turning brown in the air, fuse with Na_2CO_3.
Green mass Na_2MnO_4 indicates Mn

Filtrate Ba, Ca, Sr, Mg acetates or chlorides. Examine in usual manner.

NOTES.

I. HNO_3 is added to oxidize Fe and destroy $H_2C_2O_4$, organic acids and matter.

II. NH_4OH ppts. Fe, Al, Cr as hydrates and phosphates, and the other metals of the group as phosphates, if they are in combination with that acid, it also ppts. all of the phosphates of the alkaline earths that may be present.

Ppt. A is treated with $(NH_4)_2S$ to convert the phosphates (except those of Al, Cr, Ba, Sr, Ca and Mg) into sulphides, the H_3PO_4 is taken up by the NH_4OH in a soluble form and filtered off, thereby making a partial separation of the phosphoric acid.

III. A pink or green coloration may be caused by the oxidation of Mn to permanganate or manganate, neither interferes with the $BaCl_2$ test.

IV. Ferric salt is added to carry down the phosphoric acid, as $Fe_2(PO_4)_2$, white, solution must be alkaline with NH_4OH, when all the H_3PO_4 is pptd. the NH_4OH brings down the yellow or brown $Fe_2(OH)_6$.

V. Instead of scheme as above the following may be used :

Filt. containing Mn, Zn, Ba, Sr, Ca, Mg as acetates or chlorides add Br and boil as long as a black ppt. is formed and color of Br remains; filter.

Ppt.	Filt. Zn, Ba, Sr, Ca, Mg acetates or chlorides. Warm, pass a rapid current of H_2S, filter.	
MnO_2H_2O test in Na_2CO_3 bead.	ZnS white, if colored dark color test on charcoal with $Co(NO_3)_2$.	Filt. Boil out H_2S and proceed as usual.

A scheme for separating and detecting H_2S, HCy, H_4FeCy_6 $H_6Fe_2Cy_{12}$ HCl, H I and HBr. Boil out H_2S, test fumes with PbA_2 paper a black coloration indicates H_2S. Add $NaHCO_3$ and distil, carrying distillation to dryness, and pass distillate into KOH, test this for HCy in usual way, when cyanides are removed, cool, dissolve residue in H_2O and add $CuSO_4$ as long as a ppt. is formed, and until the liquid becomes blue or green; filter.

Ppt.	Soln.
Cu_2 Fe Cy_6 Cu_3 Fe_2 Cy_{12}	Add conc. solution of $(NH_4)_2$ Fe_2 $(SO_4)_4$ and boil, pass vapor into starch water. Blue color indicates HI when this is removed add a drop of conc. H_2SO_4 some dil $K_2Mn_2O_8$ and boil as long as Br* is given off or until the color is discharged, adding more $K_2Mn_2O_8$ if necessary. Finally test soln. with HNO_3 and $AgNO_3$, a white curdy ppt. sol. in NH_4OH and pptd. by HNO_3 indicates HCl.

NOTE.—Test for these acids in the original with Ferric and Ferrous salts.

NOTE.—So much of the above scheme as relates to separation of Cl Br and I is due to E. Hart (See *Chem. News*, Dec., 1884).

The use of $(NH_4)_2$ Fe_2 $(SO_4)_4$ is original.

WINDING ENGINES.†

BY HERBERT W. HUGHES, F.G.S.

THE tendency of all modern practice is to reduce the machine for this purpose to one with the simplest and fewest parts possible, and this may be considered to be the reason why such engines generally work at high pressure without expansion, save for the small amount given by a certain lead of the slide-valve and corresponding lap. We find that for the sake of simplicity and less cost the old beam and connections are abolished and the connecting

* Br vapor may be passed into KOH and this solution tested in the usual way.

† Reprinted from "Trans. S. Staffordshire and E. Worcestershire Inst. of Min. Engs.," vol. xii., pt. i.

rod attached directly to the crank-shaft; most modern engines are furnished with two cylinders and this must be considered one of the greatest strides yet made, as it allows the engines to be handled with more precision. Finally, we find that the succession of gearing which served to drive the drums slower than the flywheel has been abolished and the drum-shaft connected directly with the piston-rod, the drum itself now acting as the flywheel.

Summing up the above facts, we shall find that the engine at present in vogue at our large collieries has the following construction:

(1) It is furnished with two cylinders directly coupled.

(2) It is placed close to the engine-man, allowing of easy handling.

(3) The pistons are connected to the drum-shaft without the intervention of any gearing.

(4) It has some system of reversing gear.

(5) And works with high-pressure steam without condensation and with practically no expansion.

An engine constituted as above would be taken as fulfilling all qualifications of a colliery; during the last few years, however, the question of cost in maintenance has come seriously before engineers, especially as the size of the machine increased. The general remark as to fuel used is that a colliery fuel costs nothing and, therefore, the question of a few tons more or less cannot be of much moment, but fuel costs something to get, and in the succeeding pages the writer will endeavor to prove how a considerable quantity may be saved without much effort, and also how the first cost of a plant can be lessened by the substitution of smaller engines, equal in working capacity to larger ones designed on the old lines. The large engines of the present day are far more wasteful than those of previous times, even if built on the same design; they require higher pressure and more steam and, consequently, more boilers, more fuel and more labor in stoking.

The proper heads to divide the alleged improvements under would be (*a*) counter-balancing; (*b*) condensation; (*c*) automatic variable expansion; but as the latter has, up to the present, only reached the initiatory stage, the writer proposes to dwell slightly upon it. Some forms of expansion-gearing have proved very successful, but owing to the complication resulting from their application have not been received with favor. The subject-matter will

be divided into (*a*) counter-balancing; (*b*) condensation and automatic variable expansion. The former head will be treated in this paper and as the most successful application of this is due to the Koepe System of Winding, a short description of that process will conclude the paper, reserving for a future one the consideration of expansion and condensation.

Counter-Balancing.

Until lately the general practice was to let engines run without any counter-balance whatever, and even at the present time this is carried out in the majority of cases. Engines running unbalanced are subject to enormous variations in the load, for

Let W = weight of cage and empty tubs, say 6,270 lbs.
" c = weight of coal, " 4,480 lbs.
" r = weight of rope hanging down pit, " 6,000 lbs.

Now assuming the engine is about to commence to draw coals and the empty cage is at the top of the pit, the weight to be lifted will be:

$$W + c + r - W \text{ or } 10{,}480 \text{ lbs.}$$

In the centre of the run, half r will have been added to the descending load and substracted from the ascending one; we shall, therefore, get for the weight on the engine:

$$W + c + \frac{r}{2} - \left(W + \frac{r}{2}\right) \text{ or } 4{,}480 \text{ lbs.}$$

At the end of the run we obtain:

$$W + c - (W + r) \text{ or } 1{,}520 \text{ lbs.}$$

During the complete operation the load varies from 10,480 lbs. against the engine to 1,520 in favor of it. At the commencement of winding the engine wastes a large amount of energy in setting this mass in motion, and as speed is of the greatest importance, the engine-man cannot cut off steam when most desirable, but must go on, and finally has to reverse the engines in order to bring them to rest. In the latter part of the run we can therefore see the enormous amount of energy lost, and this loss will obviously increase with the depth of the pit. Supposing, now, that by one of the methods of counter-balancing, which will be described further on, the weight of rope hanging down the shaft was balanced, and

denoting this new factor by r' we get at the commencement of the run for the weight to be lifted:

$$W + c + r - (W + r') \text{ or } 4{,}480 \text{ lbs.}$$

In the centre of run we find:

$$W + c + \frac{r}{2} + \frac{r'}{2} - \left(W + \frac{r}{2} + \frac{r'}{2}\right) \text{ or } 4{,}480 \text{ lbs.}$$

and, finally,

$$W + c + r' - (W + r) \text{ or } 4{,}480 \text{ lbs.}$$

The weight to be lifted thus remains constant, and not only so, but it is considerably smaller at the commencement than in the other case. The above will be clearly understood if we remember that for every increment of decrease in r an equal increment of r' is added, and as these two forces are equal and opposite at the commencement they will necessarily be so at the conclusion.

Having thus proved the great advantage of counter-balancing, we will now consider in what form it can be best employed and in doing so will review the following methods: (*a*) tapering rope; (*b*) counterpoise system; (*c*) loaded wagon on incline; (*d*) endless rope or tail rope beneath cages; (*e*) flat ropes coiling on reels, conical and spiral drums.

Tapering Rope.—At the initial stage the tapering rope enables us to wind from greater depths than is possible with ropes of uniform section. The thickness of such a rope at any point should only be such as to safely bear the load on it at that point.

With tapering ropes we obtain a smaller difference between the initial and final load, but the difference is still considerable, and for perfect equalization of the load we must rely on some other resource. The theory of taper ropes is to obtain a rope of uniform strength, thinner at the cage end where the weight is least, and thicker at the drum end where it is greatest. However, as these ropes cost more, and owing to the difficulty of manufacture cannot be made so perfect as those of uniform section, there is not much advantage in them.

With tapering ropes we obtain a less initial dead weight on the engine, for their section at the largest point will be less than that of a rope of uniform section throughout, owing to less weight having to be supported at that point. The difference between the

initial and final load is also smaller, but it increases more rapidly, because the larger diameter is being wound on the drum in the ascending portion, while in the descending portion the larger section is being unwound. We must, therefore, look to some other methods for equalization of the load. For round ropes on cylindrical drums the endless rope and counterpoise or loaded wagon affords a strict solution of the problem, while with conical or spiral drum and round ropes, or flat ropes with reels, we can calculate a mean radius which approximately solves the question.

The Counterpoise System * consists of a heavy chain working up and down a staple pit, the motion being obtained by means of a special small drum placed on the same axis as the winding drum. It is so arranged that this heavy chain is wound up at its maximum, and therefore hangs in full length down the staple pit at the commencement of the winding; in the centre of the run the whole of the chain rests on the bottom of the pit and, finally, at the end of the winding, the counterpoise has been rewound upon the small drum and is in the same condition as it was at the commencement. We can thus see that in the introductory stage of the wind, when the engine encounters the greatest resistance, it is assisted by the whole weight of the counter-balance, and as this weight gets less the resistance against the engine diminishes, until, when we reach the centre of the pit and the two dead weights balance each other, the counter-balance has no weight whatever, owing to its position at the bottom of the staple pit. During the remainder of the run, when the descending load is acting in favor of the engine, the counter-balance chain is being wound up and thus absorbs the energy due to descending load. The smaller drum employed for actuating the counterpoise renders the employment of a deep staple pit unnecessary. If it were as large as the winding drum it will be easily seen that this shaft would have to be half as deep as the drawing one.

Loaded Wagon System.†—Another plan, formerly much employed, was to have a loaded wagon running on a short incline in place of this heavy chain; the rope actuating this wagon being connected in the same manner as the above to a subsidiary drum. The incline was constructed steep at the commencement, the inclination gradually decreasing to nothing. At the beginning of a

* In use at Monkwearmouth and Harton Collieries.

† Was in use at Killingworth Colliery.

wind the wagon was at the top of the incline and, during a portion of the run, gradually passed down it till, at the meet of cages, no pull was exerted on the engine—the wagon by this time being at the bottom. In the latter part of the wind the resistance was all against the engine, owing to its having to pull the wagon up the incline, and this resistance increased, from nothing at the meet of cages, to its greatest quantity at the conclusion of the lift. We can thus see that the distance travelled by the wagon would be twice the length of the road on which it runs, and that the force exerted by such an agent would be positive at the commencement, nil at the centre, and negative at the end. It is evident that, with a properly constructive curve, the same result will be obtained as with the counterpoise chain, and, perhaps, with less expense, owing to the sinking of a staple pit being rendered unnecessary.

The *endless rope system* is preferable to all others, if there is sufficient sump room and the shaft is free from tubes, cross timbers, and other impediments. It consists in placing beneath the cages a tail rope, similar in diameter to the winding rope, and, after conveying this down the pit, it is attached beneath the other cage. When first introduced it was thought necessary that a pulley should be placed in the sump, round which this rope should pass; this pulley remaining stationary under general conditions, but free to move between guides, if necessary; in a great number of cases, however, no pulley is used, and the rope works just as well. By this system perfect counter-balance is obtained, as you introduce a factor equal and opposite to the weight of the winding rope, which gives equality at the commencement and the end. The one solitary objection urged against this system is, that a greater weight is put on the most tender part of the winding rope, viz., the capping; but the writer contends that it ought to be sufficiently strong to bear this extra load.

With the object of proving how this counter-balancing question materially affects the size of winding engines, the writer proposes to insert here a formulæ given by Mr. Robert Wilson* on this point, and may state that he believes this formulæ to be the only true one regarding this point, it being based on the fact that the greatest work a winding engine has to do is to *get a given mass into a certain velocity uniformly accelerated from rest, and to raise a*

* *Transactions of the Chesterfield and Derbyshire Institute of Engineers.* vol. xi., p. 267.

load the distance passed over during the time this velocity is being obtained.

Let W = the weight to be set in motion: one cage, coal, number of empty tubs on cage, one winding rope from pit head-gear to bottom, and one rope from banking level to bottom.

v = greatest velocity attained, uniformly accelerated from rest.

g = gravity = 32.2.

t = time in seconds during which v is obtained.

L = unbalanced load on engine.

R = ratio of diameter of drum and crank circles.

P = average pressure of steam in cylinders.

N = number of cylinders.

S = space passed over by crank pin during time t.

C = ⅔, constant to reduce angular space passed through by crank, to the distance passed through by the piston during the time t.

A = area of one cylinder.

f = addition for friction, etc., of engine, varying from 10 to 30 per cent. of A.

B = area of cylinder, with margin for friction allowed.

D = diameter of cylinders required.

1st. Where load is balanced

$$A = \frac{\left\{\left(\frac{Wv^2}{2gt}\right) + \left(L\frac{vt}{2}\right)\right\}R}{P.\ N.\ S.\ C.}$$

$$A + f = B \therefore D = \sqrt{\frac{B}{.7854}}$$

2d. Where load is unbalanced.

The symbols will retain their significance and the formulæ will remain the same as before, with the addition of another term to allow for the variation in the lengths of the ascending and descending ropes. In this case:

h_1 = reduced length of rope in t attached to ascending cage.

h_2 = increased length of rope in t attached to descending cage.

w = weight of rope per foot in pounds.

then:

$$A = \frac{\left[\left(\frac{Wv^2}{2gt}\right) + \left\{\left(L\frac{vt}{2}\right) - \frac{h_1w + h_2w}{2}\right\}\right]R}{P.\ N.\ S.\ C.}$$

eliminating gives:

$$A = \frac{\left[\left(\frac{Wv^2}{2gt}\right) + \left\{\left(L\frac{vt}{2}\right) - hw\right\}\right]R}{P.\ N.\ S.\ C.}$$

$$A + f = B. \therefore D = \sqrt{\frac{B}{.7854}}$$

Applying the above formulæ when designing the new engines at Bestwood, Mr. Wilson found that 30 inches diameter of cylinders would produce equal results, when balanced, as the 36-inch cylinder were doing at the down-cast pit, the latter being unbalanced. We can easily see what produces such a result; L is the *unbalanced* load, and this in one case means simply the weight of coals raised per lift, and in the other the weight of coals plus the weight of rope hanging down the pit.

At Sandwell Park Colliery:

Cage weighs 32 cwt., or 3,584 pounds.

Four tubs weigh 28 cwt., or 3,136 pounds.

Weight of coal raised per lift is 4,940 pounds.

Rope weighs 3 pounds per foot.

Pressure of steam is 45 pounds.

$S = 47.2$.

$v = 35$.

$t = 7$.

$R = 3$.

Depth of pit is 1,260 feet.

From formulæ No. 1, we get:

$$A = \frac{\left\{\left(\frac{19{,}400 \times (35)^2}{2 \times 32.2 \times 7}\right) + \left(4{,}940 \times \frac{35 \times 7}{2}\right)\right\}3}{45 \times 2 \times 47.2 \times \frac{2}{3}} = 696.8$$

$$B = 696.8 + \frac{696.8}{20} = 731.6 \quad D = \sqrt{\frac{731.6}{.7854}} = 30.52 \text{ inches.}$$

We thus observe that if the balance rope was put on, the diameter of the present 36-inch cylinders might be reduced to 30½ inches. It would be impossible to say anything against the work these engines are capable of performing; during a period of 37 hours 39 minutes, 3,117 tons 11 cwt. of minerals were drawn, giving an average of 136 tons per hour, or 1,100 tons per day of eight hours. One day's draught in the same week amounted to 1,133 tons 12

cwt., in a period of 7 hours and 41 minutes, or an average of 148 tons per hour. With such results, the only objection that can be made is that the engines are too large, not as they at present stand, but if a tail rope was put beneath the cages.

The writer proposes to consider, finally, the action of *flat ropes coiling on reels.* It will be at once seen that this means of winding allows of a certain equalization, for the radius of the coil of ascending rope continues to increase, while that of the descending one continues to diminish. Consequently, as the resistance decreases in the ascending load the leverage increases, and as the power increases in the other, the leverage diminishes. The variation in the leverage is a constant quantity, and is equal to the thickness of the rope where it is wound on the drum. We shall observe that the result obtained will depend on the size of the mean radius of the drum, and this mean radius will be the one which occurs when the cages meet, because from that point the same number of revolutions in opposite directions are required to bring one cage to the surface and the other one to the bottom of the pit.

From this, it follows that the cages do not meet in the middle of the pit, but at a point below, because, at the commencement of a wind, the descending rope is uncoiled from the large diameter of the reel, while the ascending rope is coiled on the small diameter.

By the above means a remarkable uniformity in the load may be obtained, the only objection being the use of flat ropes, which weigh heavier and only last about two-thirds the time of round ones.

Results analogous to the preceding may be obtained by using round ropes coiling on conical drums, which may either be smooth, with the successive coils lying side by side, or they may be provided with a spiral groove. The objection to these forms is, that you do not get perfect equalization with the conical drums unless the sides are very steep, and consequently there is great risk of the rope slipping; to obviate this, scroll drums were proposed. They are, however, very expensive, and the lateral displacement of the winding rope from the centre line of pulley becomes very great, owing to their necessary large width.

Since this paper was written, two new methods of counterbalancing the weight of winding ropes have been brought forward and patented in Germany and England. They are the inventions of Herr C. Meinicke, of Clausthal, North Germany, and a de-

scription of them has been contributed to the *Chesterfield Institute of Engineers** by Mr. J. Clark Jefferson, from which paper the following remarks are extracted:

"Both methods possess the distinguishing feature that the balance rope is attached, at the two ends, to two auxiliary ropes, so that the balance rope may, if desired, be boxed off from the main portion of the shaft, and, what is of more importance, the shackle of the winding rope has to carry only the weight of the cage and its contents. The difference in the two methods lies in the fact that in one case the auxiliary ropes are attached directly to the winding engine, and in the other the connection is indirect."

"1ST. COUNTER-BALANCING BY MEANS OF A BALANCE ROPE CONNECTED DIRECTLY BY TWO AUXILIARY ROPES TO THE WINDING ENGINE.

"The method is represented in Figs. 1 to 3.

"C_1 and C_2 are the cages.

"W_1 and W_2 are the winding ropes.

"A_1 and A_2 the auxiliary ropes.

"B is the balance rope, and b_1 and b_2 the ends of the same.

"D_1 and D_2 are the winding drums.

"Let L be the depth of the shaft in feet.

"The auxiliary ropes wind off and on the winding drums, and the balance rope is shown hanging free in the sump, at the bottom of the shaft.

"If we suppose both cages to be equally loaded and freely suspended, the weight of the winding rope W_2 and the auxiliary rope A_2 tend to turn the drums around in the direction indicated by the arrow. This tendency is opposed by L feet of the balance rope. If, now, the weight of 1 foot length of balance rope is equal to the weight of 1 foot length of the auxiliary rope and winding rope together, the balancing is perfect. It will be readily seen that under the above supposition the balancing is perfect, or complete for all positions of the cages in the shaft.

"The auxiliary ropes and the balance rope can also be guided by pulleys into such a position in the shaft that they may be boxed off from the rest of the shaft, so that this method of counterbalancing possesses the advantage that *the open portion of the shaft*

* Vol. xiii., pp. 333–366.

can be kept clear of all accessories except the cages, winding ropes and guides; and, also, that the winding rope has no greater strain thrown upon it than that due to the cage and its contents.

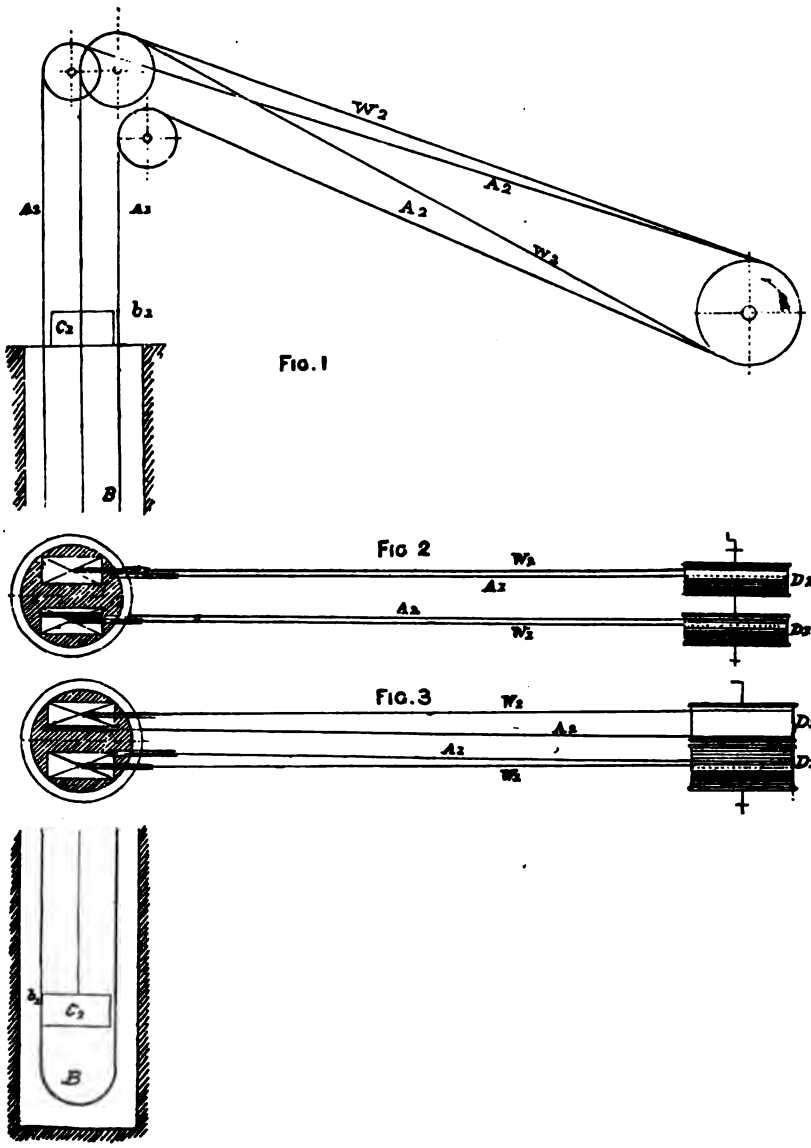


FIG. 1

FIG 2

FIG. 3

The auxiliary ropes may be attached to, and wound on and off, the same drums as the winding ropes; or the auxiliary ropes may

be attached to and wound on and off special drums on the same axis as the winding-rope drums; the special drums being attached

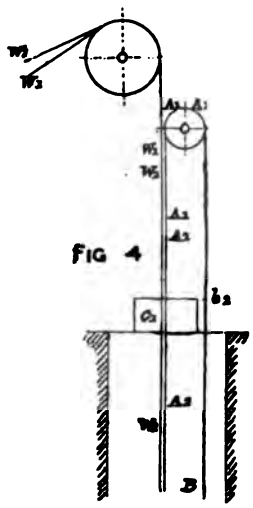


FIG 4

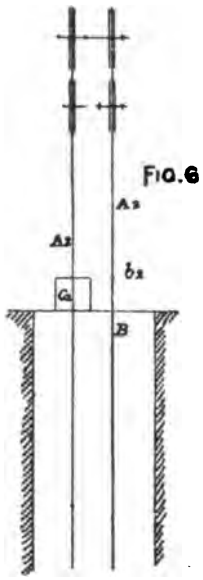


FIG. 6

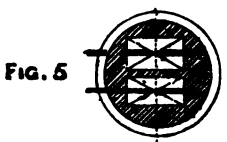
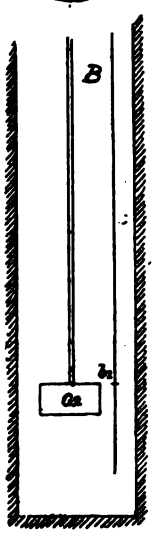
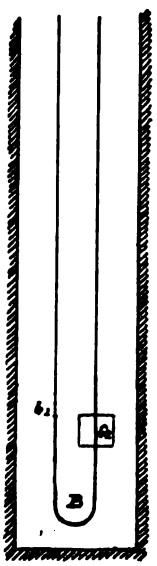


FIG. 5





to the axle by clutches (which can be readily thrown in and out of gear), and provided with brakes, by which they can be held fast when the winding drums are rotated.

"In Fig. 2, the winding drums are shown of the ordinary width, the winding rope coiled on the drum as the auxiliary rope is uncoiled, and *vice versa*.

"In Fig. 3, both winding drums are made sufficiently wide to allow of one of the winding ropes and one of the auxiliary ropes being coiled at the same time on one of the drums."

Figs. 4, 5 and 6 show the arrangement when the auxiliary ropes are not boxed off, but pass down the main shaft; they may then be each connected with the cage which moves in the same direction.

Several modifications in matter of detail are treated of, but space will not permit of a more complete description. Members interested are referred to the original paper, and also to a second one, on the same subject, by Mr. J. C. Jefferson.*

Summing up these facts, the writer has come to the conclusion that the endless rope (tail rope beneath cages) is the best system of counter-balancing, for this reason: it gives perfect equalization, from the commencement to the end, at the smallest cost, and, moreover, is very simple.

The Koepe System of Winding.

This system is the invention of Mr. Frederick Koepe, the manager of the Hanover Collieries, in Westphalia, which belong to the celebrated ironmaster, Krupp.

It may briefly be said to consist of the substitution of an iron pulley, with a single circular groove, in place of the ordinary drum. The winding rope passes from one cage, over its headgear pulley, round the drum and, after passing over the other headgear pulley, is connected with the second cage. It is therefore evident that the winding rope simply encircles about half the periphery of the drum in the same manner as a driving belt on an ordinary pulley. There is a balance rope beneath the cages, passing round a pulley in the sump; the arrangement may be likened to an endless rope, the two cages being simply points of attachment.

The first installation of this new principle in this country took place at Bestwood Colliery, and was seen in course of erection by the members of this Institute in August, 1880; since then, the writer, in July, 1884, had an opportunity of inspecting the plant when in full working order, and of convincing himself of the economy resulting from the introduction thereof.

* *Trans. Chesterfield Inst. of Engs.*, vol. xiv., pp. 230–237.

The drum pulley consists of the two outside cases of an ordinary cylindrical drum bolted together and securing between the brake rims a band of hardwood in which is cut a groove to receive the winding rope; the depth of this groove is generally made equal to twice the diameter of the winding rope, and the width at the top is regulated by the distance of the pit shaft from the centre of the drum. At Bestwood, the head-gear pulleys are angled slightly towards each other, with the object of reducing side friction on this wooden band as much as possible; and the manager informed the writer that at the present rate of wear, the wooden band would last ten years.

In the Colliery Guardian for April 2d, 1885, mention is made of an hydraulic press for compressing wood, the resulting product being very dense, uniform and close-grained. Such a wood will be especially useful for these bands; and, being very cheap, is capable of being employed, not only for this purpose, but for many others where a dense wood is required.

It is obvious that unless some means were devised to prevent it, the rope, when the cages rested on the legs at the top and bottom of the pit, would slip and the drum simply revolve without lifting anything. At Bestwood, this is prevented by connecting the winding rope to a cross-head over the cage, the balance rope being attached to a similar cross-head beneath the cage; the two cross-heads are connected by side rods passing outside the cage, which is hung on to the upper cross-head by bridle chains in the ordinary manner. As the cage is free to move a short distance up and down between these side bars, it therefore follows that when the cages rest on the legs, the entire weight of the rope still continues on the circumference of the drum. This would not be the case if the rope were lowered so far as to allow the top cross-head to rest on the cage; the rope would then slip, and consequently *overwinding is rendered impossible.* At the Sneyd Colliery, Burslem, where this system has also been adopted, the same result is obtained in a different manner. No catches are used at the top of the pit, the upper rope being kept properly adjusted, so that when the bottom cage is on the bearers the top cage is in a correct position for landing.

One objection urged against this system is that the rope is likely to slip during the progress of winding and the engine-man thus become unaware of the position of the cages in the shaft. Such,

however, is not the case. At Bestwood, the engine-man cannot see the cage when it reaches the surface, owing to winding operations being carried on at the up-cast shaft, this being covered around with an iron casing; consequently, he has to rely entirely upon the indicator, and under these conditions has not the slightest difficulty in landing the load. The writer spent half an hour watching this operation, and was very much struck with the nicety of it. It is found that when the ropes are oiled, there is a slip of about six inches in one direction, and when that amount has been reached no further deviation takes place until the next oiling. At the Sneyd Colliery, the groove in the drum is ribbed, with the object of reducing, if possible, this inconvenience—the wear being taken up by pieces of hemp rope.

Another objection urged, is that if one of the ropes broke, both cages would be precipitated to the bottom of the shaft. This might occur if the fracture took place at the drum; but, anywhere else, it would be extremely improbable, as the friction of rope over head-gear pulley and round the drum would effectually prevent any such occurrence. Ropes ought not to break; and, for this system, it is preferable to employ ropes somewhat stronger than for ordinary winding, and then no such accident would happen; the extra weight of rope would not effect the size of engines required, for there would be a complete balance. When this system was introduced at Bestwood, ropes, passing from one cage over secondary pulleys and then to the other cage, were used, so that in the event of a breakage of the winding rope, both cages would remain suspended. Owing to the wear on these pulleys, necessarily of small diameter and revolving very rapidly, they have been abandoned.

The great advantages of this system are numerous: (1) smaller engines are required; (2) no drum; (3) a smaller length of winding rope suffices; (4) and a smaller engine-house is required.

The first advantage follows from the perfect counter-balance; and as an example, the writer may cite Bestwood, where the engines have been reduced from 36 inches to 30 inches cylinder; and at the Sneyd Colliery, particulars of which are given later on.

Secondly, we dispense with the drum, this being of great importance, when we consider that in ordinary engines a drum weighing 50 tons has to be set in rapid motion and stopped in a very short space of time, and that when this motion has been obtained at the expenditure of a large amount of energy, we cannot

utilize this power and cut off steam, leaving the rest of the journey to be performed by the stored-up energy, but must go on for the sake of speed until we reach the furthest point at which the engine-man can bring his engines to rest within the given distance. In the Koepe system, owing to lightness of drum, none of this loss occurs, besides the other important point, viz.: the question of first cost. Drums are very expensive playthings,* and any system which dispenses with their enormous weight and cost is worthy of consideration, if looked at from that point alone.

With regard to the smaller length of winding rope, we can see this follows from there being no coils on the drum, a feature of economy which will largely increase as greater depths are attained. The last saving—smaller engine-house—resulting from the substitution of a drum two feet in width for one of about nine feet, and the consequent narrowing of the structure, is, perhaps, of not so much importance as the foregoing, but if the coal trade continues in its present depressed state, the consideration of even smaller items than this will become necessary.

In concluding the first part of the subject, it may be remarked that the writer considers the type of engine described above to be at the present time the most perfect. Defects were urged against the system on its first application, but its successful working has fully demonstrated the weakness of the objections. With plants already designed and erected, no alteration, as regards this point, can be expected, but where new erections are about to be put down, no engineer ought to neglect an opportunity like this for diminishing the first cost of plant. The balance rope can, however, be put on anywhere if a double shaft is available, and upon its application a less pressure of steam is required.

At the Sneyd Colliery, Burslem, engines on the Koepe system have been lately put down to draw from a depth of 370 yards, of which the following particulars have been supplied by Mr. B. Woodworth: Diameter of cylinder, 16 inches; stroke, 48 inches; drum 30½ feet in circumference; pressure of steam (in boilers), 60 pounds; weight of cage, 1 ton; two tubs, weighing 5 cwt. each, and carrying about 27 cwt. of coals, are raised per lift. Time of run, about 40 seconds; the output per hour being by experiment, 80 tons.

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* The Scroll Drum at Boldon Colliery weighs 80 tons and cost £1,500.

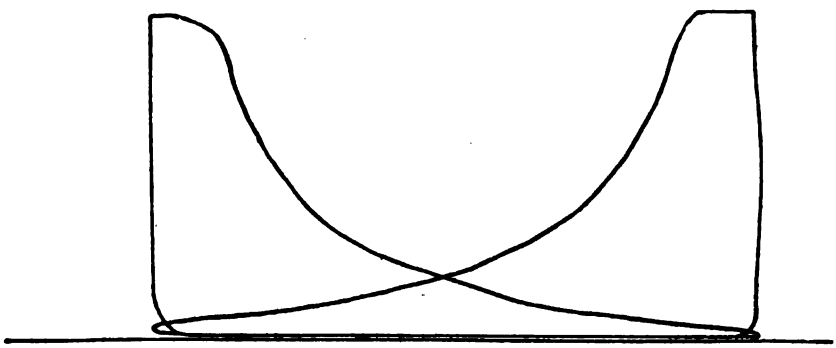
NOTES AND ABSTRACTS.

DENVER, COLORADO, March 1st, 1889.

THE SCHOOL OF MINES QUARTERLY,
COLUMBIA COLLEGE, NEW YORK CITY:

GENTLEMEN:—We take pleasure in presenting to the readers of the QUARTERLY, an indicator card taken this day, March 1st, 1889, from a 258 H. P. Hamilton Corliss Engine, at the works of The Globe Smelting and Refining Co., Denver, Colorado.

We send this card in the belief that it is exceedingly meritorious and presents many features of scientific importance. It is certainly the most



20 x 48 Hamilton Corliss Engine—8 A M., March 1st, 1889. Rev., 75; steam, 85 pounds; spring, 40.

perfect card that we have ever been able to find, whether taken in practice or indicated by any of the treatises upon steam engineering.

The conditions under which this card was taken may be briefly stated as follows:

There are four 80 horse-power boilers running at a pressure of 85 pounds each. A part of this steam was utilized for running the Corliss Engine which produced this card.

The diameter of cylinder of engine is 20 inches, the length of stroke is 48 inches. The engine was running at 70 revolutions per minute; 85 pounds of steam as indicated upon the steam-gauge in the engine room. The throttle valve was wide open. The scale of spring is 40.

The inside diameter of feed-pipe is 7 inches, the inside diameter of exhaust-pipe is 7½ inches.

At the time this card was taken there was attached to the main countershaft three No. 7 Baker blowers and one No. 7½ Baker blower. There was also a No. 10 Sturtevant exhaust fan, one grindstone, one bolt cutter machine and one drill press.

On May 31st, 1888, a card was taken from this engine showing a back pressure of 17 horse-power; another card taken December 21st, 1888,

showed that we were developing 182.2 horse-power, and that there was a back pressure of 14 horse-power. These data were very accurately ascertained by Messrs. Hoover, Owens & Rentschler, of Hamilton, Ohio, the builders of the engine. Quite recently we have been modifying and changing our valve motion until we have arrived at the card presented.

According to our best information this card shows less than 1 horse-power back pressure. Exactly how much less we will not state at present. There is developed 157 horse-power.

The results we have recently obtained reflect much credit upon our engineer, Mr. David B. Higgins, who has carefully adjusted our valve motion.

We are, very truly yours,

THE GLOBE SMELTING AND REFINING CO.

MALVERN W. ILES, Superintendent.

Universal International Exposition of 1889. International Congress of Mines and Metallurgy.

The French government has appointed an International Congress on the subject of Mines and Metallurgy, to be held in Paris on the 2d of September in this year, in connection with the Exposition which is to take place there during the next summer. The Congress has for its object to make known and discuss the most recent inventions and improvements in mining and metallurgy, and will have brought before it a considerable number of memoirs which have been prepared by engineers specially detailed for the purpose. These reports will be printed and distributed in advance to persons who wish to become members of the Congress and will form the basis of the discussion. But other subjects may be introduced, or other questions presented by the members, with the approbation of the officers in charge.

The Congress will consist of members and honorary members, the honorary members being appointed by the French government, and the members becoming so upon the payment of 20 francs.

Letters and communications from this country relating to the subject of Mines and Metallurgy may be addressed to Mr. Castel, inspector-general of mines and president of the organizing commission, 144 Boulevard Raspail, Paris.

The Committee appointed by the French government consists of:

President: Mr. Castel, inspector general of mines, president of the Society of Mineral Industry.

Vice-Presidents: Mr. Brüll, past-president of the Society of Civil Engineers in Paris; Mr. Haton de la Goupilliere, member of the Institute, inspector-general of mines, director of the School of Mines of Paris; Mr. Jordan, professor of metallurgy at the Central School, past-president of the Society of Civil Engineers of Paris; Mr. Rémaury, civil engineer of mines.

Secretaries: Mr. Dujardin-Beaumetz, secretary of the central committee of coal mines; Mr. Gautier, civil engineer of mines; Mr. E. Gruner, civil engineer of mines; Mr. Lodin, engineer of mines, professor of metallurgy at the School of Mines in Paris.

Universal International Exposition of 1889. International Congress of Applied Mechanics.

The French government has organized an International Congress for Applied Mechanics, which will be held in Paris at the Conservatoire des Arts et Métiers on the 16th to the 21st of September, 1889. The preparations necessary for this Congress have been put under the patronage of an honorary committee, which comprises the names of a large number of scientific men and engineers, both in France and other countries. The president of this commission is Mr. Phillips, inspector-general of mines, retired, and the secretary is Mr. Boudenoot, civil engineer of mines and member of the committee of the Society of Civil Engineers.

At this Congress, among the important subjects submitted for discussion are, the unification of the horse-power; the choice of materials in machine construction; the mechanical production and utilization of artificial cold; transmission to a distance, and distribution of work, by other means than electricity (water, air, steam, cables, etc.); automatic cut-off engines with several successive cylinders; thermo-motors other than the steam-engine.

Other topics, treated by papers, will be: improvements in steam-engines since 1878; progress among associations of owners of steam appliances; and improvements in apparatus for the generation of steam (more particularly sectional boilers).

The organization is:

President: Mr. Phillips, member of the Institute, inspector-general of mines, retired.

Vice-Presidents: Mr. Gottschalk, member of the consulting committee for railways, past-president of the Society of Civil Engineers; Mr. Farcot, constructing engineer, past-president of the Society of Civil Engineers.

Secretaries: Mr. A. Tresca, professor at the Central School, member of the Council of the Society for the Encouragement of National Industry; Mr. Nansouty, chief editor of the *Génie Civil*; Mr. L. Boudenoot, civil engineer of mines, member of the committee of the Society of Civil Engineers.

Analytical Chemistry.

Dithio Carbaminate as a Reagent, J. Klein (*Chem. News*, lix., 76) (*Fres. Zeits.*, xxviii., 90).

This is made by passing NH_3 gas into alcohol and adding carbon disulphide. At 30° C. it crystallizes out.

It gives an easily manipulated precipitate in hot solutions of copper, decomposable by nitric acid and soluble after long boiling in hydrochloric. Other metals of the 5th and 6th groups should be absent.

It precipitates zinc from a solution weakly acid with acetic; an excess of the reagent redissolves the precipitate, which is again precipitated by boiling—too long boiling gives some zinc sulphide. Fe, Mn, Ni and Co are not precipitated by the reagent if the solution is hot, and acid with hydrochloric. The reagent has no particular advantage as a means for separating zinc and copper.

Peroxide of Hydrogen in analysis. F. P. Dunnington (*Chem. News*, lix., 76) (*Jour. Analyt. Chem.*, ii., part 4).

PbO_2 is readily dissolved in nitric acid with the aid of H_2O_2. Also the higher oxides of Mn and cerium in HCl or other acids.

The reactions of Chromium and Manganese with hydrogen peroxide are given by A. Carnot (*Chem. News*, lix., 15) (*Bull Soc. Chem.* [3], i., 275).

H_2CrO_4 in cold acid solution is reduced to Cr_2O_3; in hot alkaline solution is oxidized to chromate. Chromium may thus be separated from iron and some other bases by rendering their solution alkaline, adding H_2O_2 and boiling out the excess,—filtering off the bases precipitated, and, after rendering the solution acid, reducing the chromate by H_2O_2. If a standardized solution of H_2O_2 is used, the Cr may be thus titrated, or after reduction it may be precipitated as phosphate by adding alkaline phosphate, then excess of alkaline acetate, and boiling for ten or fifteen minutes. Manganese in alkaline solution is precipitated by H_2O_2 as MnO_2, the precipitate, however, is always contaminated with fixed alkaline salts if present, and must be redissolved and reprecipitated once or twice. Ferrous salts are promptly oxidized by H_2O_2, whether in cold or in hot solution.

Hydrogen Peroxide as a reagent, McCulloch (*Chem. News*, lix., 35).

The oxide precipitated from manganese solutions is variable, approaching Mn_7O_{13}.

Nitrite separation of Nickel and Cobalt.

Baubigny (*Comptes Rendus* 107, 685), states that lead is sometimes an impurity in the alkaline nitrite used in the process, which causes a precipitation of a portion of the nickel.

Impure reagents, de Koninck.

Reagent.	*Impurity.*
PbO_2	MnO_2
Ether	S
Chloroform.	Alcohol.

For *caustic alkali in presence of carbonate, etc.*

L. Dobbin (*Jour. Soc. Chem. Ind.*, vii., 829) utilizes the fact that the Nessler reagent gives no reaction unless free ammonia is present. He therefore prepares a modified Nessler reagent, 5 gms. KI are dissolved in water, $HgCl_2$ solution added until the precipitate is just permanent; then about 1 gm. NH_4Cl is added and the whole is diluted to 1 litre. When enough caustic alkali to set free *all* the NH_3 is added, a coloration is produced. Alkaline carbonates and sulphates have no effect. After obtaining a certain tint with known amounts of caustic soda, it was possible to find how much of a substance to be tested was required to produce the same tint, and thus the reaction was made quantitative. Sulphides, of course interfere.

Determining lithia by means of Fluorides, A. Carnot (*Bull Soc. Chim.* [3], i. 280).

KFl is very soluble in water, NaFl is less so, requiring 25 parts of cold water. LiFl requires about 800 parts of water, or 1900 parts of a mixture of equal parts of water and ammonia. The solubility is further decreased by addition of NH_4Fl to 1 in 3500.

The reagent used is NH_4Fl. It requires purification by dissolving, adding ammonia, boiling up and filtering. The solution containing lithia is concentrated to small bulk, NH_4Fl and excess of ammonia added, and after stirring well it is allowed to stand over night. It is then washed by decantation with NH_4Fl and ammonia solution. The precipitate is then calcined, sulphuric acid added, and the lithium weighed after ignition as sulphate. An allowance of 0.002 gram lithium fluoride for every 7 cc. of filtrate and washings is made.

In mineral waters after evaporating and removing all bases but magnesium and the fixed alkalies, as chlorides, the solution is evaporated until the salts crystallize out and the mass extracted with 90 per cent. alcohol, finally with alcohol and ether. The solvent is distilled off, and the separation of the lithia effected as described above. Magnesium, if present, will be precipitated with the lithia. It must be determined as phosphate, and deducted accordingly. The ratio of the weight of the LiFl to that of the Li_2SO_4 is very nearly 1 : 2. This fact is of value as a check on the work.

Analysis of substances containing lime, alumina and magnesia, L. Blum (*Fres. Zeits. Anal. Chem.*, xxvii., 706).

In precipitating iron and alumina by ammonia, in presence of lime and magnesia, the precipitate is not free from lime and magnesia, unless it is redissolved and reprecipitated. Long boiling of the solution after addition of the precipitant also gives incorrect results.

Rapid reduction of Ferric iron in analysis, C. Jones (*Trans. Inst. Min. Eng.*, N. Y., Feb., 1889).

The solutions are reduced by filtration (with the aid of a pump) through pulverized zinc. An apparatus especially designed for the purpose is figured and described.

Titanium in Silicates, P. Holland (*Chem. News*, lix., 27).

Riley's statement that there is a loss of TiO_2 by heating with HF in the absence of H_2SO_4 was confirmed by experiments.

Experiments on the precipitation of TiO_2 by boiling the neutralized solution from the bisulphate fusion after adding SO_2, showed that the first boiling gave a precipitate containing something other than TiO_2, and a second fusion and precipitation gave a precipitate still containing a little iron, but weighing less than the amount of TiO_2 added. To analyze silicates, the author recommends decomposing with HF and H_2SO_4, dissolving in HCl, making a basic acetate precipitation to obtain the combined weight of Al_2O_3, TiO_2 and Fe_2O_3, redissolving by means of bisulphate fusion, precipitating by reduction and boiling, repeating this operation to purify the TiO_2, and in another portion precipitating the

iron as sulphide in presence of tartrate, dissolving, precipitating and weighing as Fe_2O_3. The Al_2O_3 was determined by difference. Phosphoric acid, if present, requires a modification of this plan.

Titanium and Phosphorus in iron ores, Jennings (*Eng. and Min. Jour.*, xlv., 675).

Dissolve 1 to 5 gms. in hydrochloric acid—neutralize, reduce the iron by sulphurous acid, add acetic acid, and precipitate by boiling. Extract the phosphoric acid from the precipitate by fusion with sodium carbonate, and dissolving in water.

Sulphur in manufactured iron, C. Meineke (*Zeits. Angew. Chem.*, 1888, 376).

Treat 5 gms. of the iron with cupro-ammonium chloride in 250 c.c. of hot water, then add 10 to 15 c.c. of hydrochloric acid, and heat until the metallic copper is dissolved (about 15 minutes). Filter through asbestus, wash with hot water, add potassium chlorate, then 5 cc. nitric acid (gr. 1.4), and 10 c.c. hydrochloric (gr. 1.19), heat, evaporate to dryness, evaporate with hydrochloric acid to expel nitric acid, dilute, filter and precipitate with barium as usual.

Silicon in Ferro Silicons, H. J. Williams (*Trans. Inst. Min. Eng.*, N. Y., Feb., 1889).

Where the silicon is high, the metal may resist acids. Fusion for 15 or 20 minutes over the blast with Na_2CO_3 will, however, get it into a form readily attacked by HCl. During the fusion CO is given off. Borax may be used instead of Na_2CO_3, but affords no advantages. Results by fusion with $KHSO_4$ gives uncertain results.

Separation of Aluminium and Zirconium, I. T. Davis (*Amer. Chem. Jour.*, xi., 26).

Sodium iodate is the reagent used in a solution, neutral or feebly acid, with HCl. After adding an excess of the reagent, the solution should be heated for about 15 minutes, and then allowed to stand for 12 hours before filtering. The precipitate, which appeared to be a zirconium oxyiodate, carries with it some sodium iodate, and after washing should be redissolved in HCl and precipitated with ammonia for weighing. Iron must not be present when the separation is undertaken.

Separation of Zinc and Nickel, H. Baubigny (*Comptes. Rend.*, cviii., 236).

Dissolve the mixed salts in water containing 100 c.c. glacial acetic acid per litre, treat at the ordinary temperature with hydrosulphuric acid, and allow to stand for two to three hours before filtering. Wash with hydrosulphuric acid water containing 10 per cent acetic acid. Precipitate the nickel from the filtrate at 70 to 75°, allowing the solution to cool in a stoppered flask, an excess of hydrosulphuric acid being present.

For separating Zinc from manganese and other members of that group.

Neumann (*Fres. Zeitschr.*, xxviii., 57) reconfirms Bragard's assertions as to the facility and accuracy with which this is accomplished, by passing H_2S into the solution made acid with formic acid.

Volumetric estimation of Cobalt in presence of Nickel, Manganese, etc., N. McCulloch (*Chem. News*, lix., 51).

The process depends on the conversion of potassium cobaltocyanide into cobalticyanide by means of an excess standard solution of dichromate, and then estimating the amount of dichromate in excess, by adding excess of standard ferrous solution and titrating back with dichromate. The conversion of the cobalt compound must be conducted in a flask from which the oxygen of the air is excluded. The excess of potassium cyanide used in the first instance to obtain cobaltocyanide is destroyed by use of a solution of $NiSO_4$. Copper and iron interfere with the estimation and must be previously separated.

To determine arsenic in wall papers, textile fabrics, etc.

Fresenius and Hinz recommended (*Dingl.*,271, p. 81, from *Fres. Zeits.*, xxvii., 179) the so-called Swedish distillation method. Twenty-five gms. of material are digested for an hour with 250 c.c. concentrated HCl in a retort, then 5 c.c. of a cold saturated solution of ferrous chloride is added, and the mixture is distilled until foaming stops it. 200 c.c. of water are placed in the receiver, the exit from which is through a Peligot bulb containing water. About 100 c.c. more of HCl is added and the distillation repeated, H_2S is passed into the distillate, which precipitates arsenic and some organic compounds. The precipitate is treated on an asbestus filter with hydrochloric acid containing bromine, and the solution redistilled with ferrous chloride. From this second distillate pure As_2S_3 is precipitated by H_2S.

To Detect Antimony in Minerals.

A. Johnstone (*Chemical News*, lix., 15), moistens the white coating obtained on charcoal or in an open tube with a drop of $(NH_4)_2S$. The orange color thus obtained is distinctive for Sb.

Volumetric Methods for Antimonic Acid. Knorre (*Zeits. Angew. Chem.*, 1888, 155).

Weil's method.—Addition of $CuCl_2$ boiling, and running in a standardized solution of $SnCl_2$ until the color is discharged, is rapid, but not very sharp. Weller's method, reducing from $SbCl_5$ to $SbCl_3$ by KI, distilling and titrating the iodine, is good. Herroun's method, the same reaction as the last, but without distilling the iodine, is unsatisfactory, the results being usually low, the reaction being incomplete except when the solution is hot. Fleischer's method, conversion of the antimonious into the antimonic compound by iodine in alkaline solution, gives good results with the modifications used by the author, as follows: complete reduction of the (acid) solution is insured by boiling with sodium sulphite, added little by little, and the SO_2 boiled out. A few drops of phenol phthalein are added, then caustic potash to alkaline color, followed by tartaric acid to decolorization, and finally the solution is supersaturated with sodium bicarbonate, and titrated with iodine solution.

Quantitative Analysis by Electrolysis (Classen and Schell, *Ber.*, xxi., 2892).

Separation of Sn and Sb. Dissolve sulphides in Na_2S. Electrolysis will deposit only Sb; add $(NH_4)_2SO_4$ and heat gently, gives $(NH_4)_2SnS_3$ from which Sn may be separated by electrolysis.

Or, for Sn, oxidize the SnS_2 with H_2O_2, when decolorized, acidulate with H_2SO_4 which precipitates H_4SnO_4, neutralize with ammonia, and add a litte H_2O_2, heat to destroy the last reagent, let settle, and filter off the stannic acid, dissolve in hot oxalic acid. filter, add $(NH_4)_2C_2O_4$, and electrolyze. *Copper* is only slowly deposited from an oxalate solution, the rapidity is increased by frequent additions of small amounts of a cold saturated solution of oxalic acid.

Separating SnO_2 from WO_3, Donath and Müllner (*Chem. News*, lix., 73).

The mixture of oxides from alloys after treating with HNO_3 is ground in a mortar with twice its bulk of zinc powder, and then ignited fifteen minutes in a covered crucible; treat with HCl until no more hydrogen evolved, cool, add $KClO_3$ to oxidize to WO_3, dilute with 1½ volumes water, let stand twenty-four hours, wash the WO_3 with dilute HNO_3 and weigh. Determine Sn by difference or by precipitating the filtrate with H_2S.

Cu_2O in Metallic Copper, F. P. Dewey (*Jour. Analyt. Chem.*, iii., 33).

The reaction between neutral solution of silver nitrate, and cuprous oxide in metallic copper was given by Hampe as

$$3Cu_2O + 6AgNO_3 + 3H_2O = 4CuO, N_2O_5, 3H_2O + 2Cu(NO_3)_2 + 6Ag,$$

or, that two-thirds of the copper existing as cuprous oxide remained insoluble.

The author made some experiments with coppers containing 16.67 per cent. and less of Cu_2O, and decided that the equation was more accurately represented by

$$4Cu_2O + Cu + 6AgNO_3 + 6H_2O = 2H_6Cu_4N_2O_{12} + Cu(NO_3)_2 + Ag_6,$$

or, that *all* of the Cu_2O present is converted to basic nitrate ($4CuO, N_2O_5, 3H_2O$).

Volumetric for Lead, Yvon (*Chem. Zeit. Rep.*, xiii., 16).

The titration must be conducted in acetic acid solution free from nitric acid. The solutions required are, 15.987 gms. $Pb(NO_3)_2$ per litre, 1 c.c. = 0.01 gm Pb; 10.201 gms. K_4FeCy_6 per litre; 1 gm. Fe_2Cl_6 per 250 c.c. as indicator. The "drop test" is used (a drop of solution in contact with one of the indicator on a porcelain plate) to determine when an excess of the ferrocyanide has been added.

Estimation of Iodine, Stortenbeker (*Rec. Trav. Chim.* vii., 141).

When in combination with chlorine, decomposition with KI the author finds unsatisfactory. He prefers distillation with ferrous sulphate, avoiding excess, or a mixture of ferrous and ferric sulphates. The same method can be applied to iodates.

Estimation of hydrochloric acid and chlorine when mixed, W. Younger (*J. S. C. I.*, viii., 88).

Applied to the gases from the Deacon process. The gases are aspirated by means of a graduated aspirator, through a solution of arsenious acid to which has been added a little indigo paste by way of indicator.

The gases before reaching the aspirator also pass through a solution of potassium iodide, which also serves as indicator at the same time serving to show whether the aspiration is progressing too rapidly. The arsenious acid solution (100 c.c.) is of such a strength that 1 c.c. = 0.01 gms. chlorine. When the arsenious acid has all been converted to arsenic acid (shown first by the potassium iodide tube, and shortly after by the bleaching of the indigo), the aspiration is stopped, the volume aspirated read off and the arsenic acid solution titrated with standard silver nitrate. The amount of combined chlorine, over and above that resulting from the reaction with the arsenious acid, is due to the hydrochloric acid in the gases.

Phosphoric and Hydrochloric Acid, Alkalimetric Determination of, Linossier (*Bull. Soc. Chim.*, l., 353, 354).

The phosphoric acid is precipitated from nitrate solution, hot, by excess of bismuth nitrate, the precipitate suspended in water, decomposed by H_2S. and the phosphoric acid thus free, titrated, using methyl orange as indicator (neutral to NaH_2PO_4). Chlorine is determined in a similar manner, being precipitated from the solution by silver or mercurous nitrate, the precipitate decomposed by H_2S and the free acid titrated.

Volumetric Determination of Phosphoric Acid with Molybdate, Grete (*Ber.* xxi., 2762).

In presence of gelatine, etc., the precipitate is white and subsides readily. The end reaction consists in absence of precipitation. The solutions used are:

1. Molybdate; dissolve in weak ammonia, 1000 gms. ammonium molybdate, add 100 gms. gelatine, a little nitric acid and water, and boil. The weakly alkaline solution is mixed with 3 litres of nitric acid (1.2) diluted to 10 litres, it is then left to stand some days, agitating from time to time. Decant.
2. Nitrate of ammonium; 750 gms. with 40 gms. Na_2SO_4 in 1 litre.
3. Gelatine; boil up 100 gms. gelatine with 50 gms. nitric acid and dilute to 1 litre. (Insure the absence of P_2O_5.)

Make the solution to be tested nearly neutral to methyl orange, if a precipitate forms redissolve in a few drops of HNO_3, add an equal volume of ammonium nitrate solution (2), then 1 c.c. of gelatine solution (3), warm to 80° or 90°, add the molybdate solution (1), drop by drop, until a precipitate ceases to form.

Phosphoric Acid in Basic Slags, A. v. Reiss (*Zeits. Angew. Chem.*).

Ten gms. of the slag are weighed out, a little water and 50 c.c. concentrated HCl added, it is then boiled for a few minutes, 50 c.c. concentrated sulphuric acid added and evaporated to fumes of SO_3. After cooling for fifteen minutes 100 c.c. of water is added, and the mixture is heated and stirred until it turns green. If the heat is too high, an insoluble red precipitate containing some phosphoric acid will form. The solution is cooled and diluted to 504 c.c. (the extra 4 c.c. being added to compensate for the bulk of the precipitate). After filtering 32 c.c. are taken, and to this is added 10 c.c. of the citric solution and 25 c.c. of

ammonia (Gr. 0.92), and the solution cooled. Then 25 c.c. of magnesium mixture is added and the mixture stirred. When the precipitate begins to form an additional 20 c.c. of ammonia is added. After stirring for ten minutes this is filtered, the precipitate being washed, ignited and weighed as usual.

Phosphoric Acid, A. Stutzer (*Chem. Zeit.*, xii., 492).

For rapid and convenient precipitation of the magnesia compound in presence of citrate the author recommends the addition of a small amount of pulp of an ashless filter-paper and stirring in well for five minutes with a mechanical stirrer.

Water Analysis. Loss on Ignition, T. M. Drown (*Chem. News*, lix., 82) (*Technology Quarterly*, Dec., 1888).

The dish rests on a coil of platinum wire inside of an iron capsule of the same form as the dish. A radiator of platinum is hung above and the heat applied to the outside of the iron capsule. Results obtained by this were very constant.

The Soap Test for Hardness of Waters

is adversely criticized by A. H. Allen (*Jour. Soc. Chem. Ind.*, vii, 795) as anomalous and misleading. It is affected in different hands by time, temperature, the mode of adding the soap solution, the manner of shaking, the appearance and duration of the lathers and the *sound* on shaking. Skilled chemists disagree by fifty per cent. in their results. With some colliery waters Mr. Allen found its indications to be below the truth by varying amounts. Wanklyn's assertion (in effect) that in the soap test $3CaO = 2MgO$ he found not only incorrect, but with mixtures of known amounts of $CaCl_2$ and $MgSO_4$ the hardness was less than the sum of the two taken separately, *e.g.*, a mixture which should have shown 13.7 showed about 11. The addition of ammonium oxalate and of other alkaline salts to a solution containing magnesia, diminished the hardness by the soap test. Wanklyn's plan of determining magnesium, by precipitating with oxalate, filtering and using the soap test is consequently untrustworthy.

Colorimetric Determination of Iron in Waters, A. F. Jolles (*Chem. Zeit. Rep.*, xiii., 8).

The intensity of color produced by ammonium sulphocyanate is the basis for the process. To 100 c.c. of the water, 5 c.c. of the sulphocyanate solution (75 gms. per litre) and 1 c.c. dilute hydrochloric acid are added. The comparison liquid is made from a solution of iron ammonia alum (0.4306 gm. per litre), 1 c.c. = 0.00005 Fe or 0.00007 Fe_2O_3, a little hydrochloric acid having been added to assist solution.

Nitrates in Waters, S. C. Hooker (*Ber.*, xxi., 3302).

Two c.c. or less of the water is mixed with 4 c.c. concentrated sulphuric acid, and after cooling, a small amount of concentrated sulphuric acid, containing dissolved carbazol, is added. Nitrates produce a green coloration. The amount may be determined by comparative experi-

ments with a solution containing known amounts of pure KNO_3. If the water contains less than two millionths of nitrate, it must be previously concentrated.

Determining Nitrous Acid in Presence of Nitric, W. Kalman (*Dingl.*, 271, 47).

Hydriodic acid is added, and the nitric oxide is measured over an alkaline solution of sodium hyposulphite. The hydriodic acid solution is prepared by dissolving iodine in potassium iodide, and adding sodium sulphite just to decolorization.

$$Na_2SO_3 + I_2 + H_2O = Na_2SO_4 + 2HI.$$
$$NaNO_2 + 2HI = NaI + NO + I + H_2O.$$

The hydriodic acid solution is stated to be more delicate as a qualitative reagent than the diphenylamine test.

Action of Iron Pipes on Water, Harvey (*Analyst*, xiv., 34).

A very considerable proportion of the nitrates was removed by passage through five or six miles of iron pipe (presumably rusted).

Electrolytic Conductivity.

As applied to quantitative determinations is the subject of a paper by E. Reichert (*Fres. Zeits.* xxviii., 1). The apparatus, etc., is described in detail. Fairly accurate results were obtained by this means in determining the aggregate mineral salts in sugar solution and in drinking waters.

Gas Analysis, incompleteness of Combustion in Gaseous Explosions, Dixon and Smith (*Chem. News*, lix., 65).

Nearly 1 per cent. of the mixed gases was usually found to have escaped combustion in the experiments made.

Electrolytic Deposition of Cobalt, H. N. Warren (*Chem. News*, lix., 64).

Use the chloride, with enough of saturated solution of Rochelle salt to redissolve the precipitate which first forms. Connect the object with negative pole of any single cell battery. Connect the positive electrode with a zinc rod, in a saturated solution of NaCl or NH_4Cl, in a porous cup. Ni, or a mixture of the two, can be deposited by the same means; also zinc.

MINERALOGY.

An Apparatus for Separating the Mineral Constituents of Rocks.

The following is a description of one of the best and most convenient forms of separating apparatus.

It consists of a glass urn-shaped vessel, v, (Fig. 1), the lower part of which, n, is drawn out into a neck, and ground so as to fit accurately into the top of a glass bottle b. This bottle, b, has vertical sides, a projecting lip, l, and a firm broad base, which gives support to the whole apparatus.

An important feature of this apparatus is the glass stopper, s, (Fig. 2), which is used instead of a stopcock.

When a separation is to be made place the vessel, v, upon the bottle, b, as shown in Fig. 1. Pour in the separating liquid, and then the powdered rock. Put the upper cock in, and shake the whole apparatus; after which allow the grains to settle. The heavy grains, or those whose

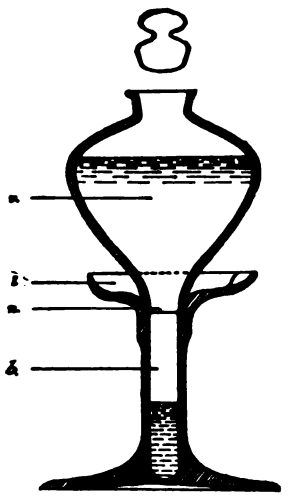


FIG. 1.

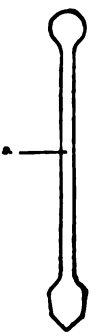


FIG. 2.

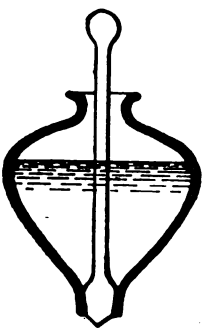


FIG. 3.

specific gravity is greater than that of the liquid, will collect in the lower part of b. Now introduce the long stopper, s, through the upper opening, move it around in the liquid a few times to prevent any particles adhering to its bottom, and then press it firmly home as shown in Fig. 3.

Remove the upper part, v, and you are ready to dilute the liquid and proceed with the separation. For rapid work it will be found convenient to have a second bottle similar to b.

The specific gravity of any separation can be approximately estimated by immersing the plummet of a Westphal's balance in the liquid in b. The required specific gravity lying between that of the liquid in b, and that of the liquid just before the mineral sank.

The advantages of this apparatus are as follows:

No stopcocks are used.

The diameter of b is larger than that of the tubes used in the old form of apparatus.

The apparatus can stand by itself.

A rough and cheap form of this apparatus can be made from an ordinary funnel. Cut off all but a half inch of the stem and connect this, with a rubber tube, to a piece of glass tubing to serve as a bottle. Another piece of glass tubing, or a rubber cork at the end of a glass rod, can be used as a stopper.

Taken from an article by W. F. Smeeth (Petrological Laboratory, Trinity College, Dublin). Communicated by Professor Sollas, in the *Scientific Proceedings of the Royal Dublin Society.*

A Method for Determining the Specific Gravity of Substances in the Form of Powder.

Melt a little vaseline in a watch-glass, to which a small platinum wire has been fused. Remove any air bubbles with a piece of filter paper, cool, and weigh in water. Let w_1 = weight of watch-glass and vaseline in water. Let the water drain off, and remove any drops that may remain with a piece of filter paper. Melt the vaseline again, and add the powder, which will be completely enclosed by the vaseline. Cool and weigh again in water. Let w_2 = weight of watch-glass, vaseline and powder in water. If W = weight of powder used, then $W-(w_2-w_1)$ = weight of water displaced. The required specific gravity of the powder is therefore $= \frac{W}{W-(w_2-w_1)}$

According to Mr. W. F. Smeeth this is the only method known which is independent of the specific gravity of the vehicle used.

Examples of the Accuracy of this Method.

Substance Used.	Sp. gr. by Vaseline.	Sp. gr. by Naumann.
Labradorite, ...	2.723	2.728
Quartz, ...	2.63*	2.65
Oligoclase, ...	2.658 / 2.661	2.659

Taken from an article by W. F. Smeeth (Petrological Laboratory, Trinity College, Dublin), in the *Scientific Proceedings of the Royal Dublin Society*. Communicated by Professor Sollas.

Mélanophlogite.

A specimen of this curious mineral examined by F. Pisani gave the following results: The mineral occurs coating a geode of limestone and sulphur in small, sharp, colorless cubes about 2 m.m. on a side and with the greater part of each face roughened by confused crystals. H., 7 approx. G., 2.02.

Before the blowpipe it blackens without fusing. Insoluble in acids. The analysis gave SiO_2, 91.12; SO_3, 5.30; Fe_2O_3, Al_2O_3, 0.43; loss by heating, 1.52. Total, 98.37. The becoming black by calcination was attributed to some undetected organic matter.—*Bull. Soc. Franc. Min.*, Dec., 1888, Tome XI., 298

The Crystalline Form of Neochrysotite.

This mineral, previously described as a manganiferous variety of chrysolite, and found only in the Vesuvian lava of 1631, has been further examined by E. Scacchi, the results placing the mineral nearer Fayalite.

Two types of crystal are described: thin, minute, rectangular or quadratic plates; and six-sided plates of varying thickness. The observed forms are $\infty \breve{P} \infty$, $2 \breve{P} \infty$, which are always present; ∞P, $\infty \breve{P} 2$, $\infty P \infty$, which are frequently present; and oP, $\infty \breve{P} 3$, P, which occur seldom and are always very minute.—*Groth Zeit. für Kryst.*, XV. Band, 293, 2 u. 3 heft.

* This sp. gr. is apparently low for quartz, but the powder, under the microscope, was found to contain air-bubbles.

Dumortierite.

The so-called Indicolite of Harlem has proved to be this rare blue orthorhombic silicate of alumina. It occurs in a biotite gneiss scattered in blue, dichroic, thread-like fibres through quartz and associated with tourmaline. Crystals are rare, but the prismatic angle of 124° (approx.) and cleavages parallel to the three pinacoids, have been observed. Carefully separated from the tourmaline, the analysis showed SiO_2, 31.44; Al_2O_3, 68.91.

The same mineral has been found in a granular quartz rock at Clip, Yuma County, Arizona, in fine blue fibres so abundant as to color the rock. The analysis showed, in addition to Al_2O_3 and SiO_2, a certain percentage of B_2O_3 and H_2O, and the percentages agreed closely with the formula $3Al_8\ Si_2O_{18}$. $Al\ B_2O_6 + 2H_2O$.—*Am. Jour. Sci.*, 3 s. Vol. XXXVII., p. 216, March, 1889.

A third new locality for this mineral is a quarry recently opened near Brignais Rhone (France). It is found sparingly in pegmatite associated with a dark green chlorophyllite.—*Bull. Soc. Franc. Min.*, Tome XI., p. 264, Nov., 1888.

Bertrandite.

This mineral has recently been identified at the Herderite locality, Stoneham, Maine, and the crystalization is described by Penfield in *Am. Jour. Sci.*, March, 1889. In the current number of *Groth. Zeit. f Kryst.* (XV. Band., 194, 2 u. 3 heft.), Carl Vrba gives crystallographic and chemical analyses of the Bertrandite of Pisek, deducing the formula $H_2Be_4Si_2O_9$.

Monazite as an Accessory Element in Rocks.

Mr. John Gordon, of Rio de Janeiro, found that by panning the sands of the beaches about that city he could obtain yellow and white grains similar to the Monazite sands of Bahia. Mr. O. A. Derby, has since made some scores of panning tests upon ground material from the neighboring rocks, and finds that all the tests made upon gneiss, granite and syenite, have given, in addition to Zircon, a greater or less quantity of a heavy yellow mineral, apparently Monazite.

The basic eruptive rocks examined, diabase, quartz diorite, mica diorite and minette, afforded no trace of the yellow mineral.—*Am. Jour. Sci.*, 3 s. Vol. XXXVII., p. 109, Feb., 1889.

Langbanite.

Igelström describes a mineral occuring in lamellar rhodonite, at Sjögrufvan, Sweden, which agrees in all physical characters with the Langbanite, of Langban. No analysis was made on account of scarcity of material.—*Bull. Soc. Franc. Min.*, Tome xi., 297, Dec., 1888.

Pyrargyrite and Proustite.

The following are some of the results of an elaborate study of the specimens of Pyrargyrite and Proustite in the British museum by H. A. Miers and G. T. Prior.

"Proustite and Pyrargyrite may always be distinguished as separate species."

"Proustite has R ∧ R 72° 12′, G 5.57. Pyrargyrite has R ∧ R 71° 22′, G 5.85."

"The two minerals may be perfectly distinguished by the colors of their powder. That of Proustite is the red of scarlet cinnabar, that of Pyrargyrite is purple red."

"Pyrargyrite is *certainly*, and Proustite *probably* hemimorphic."

"Of the occurring crystalline forms, some are characteristic of Proustite, others of Pyrargyrite, while a number are common to both."

"Most Pyrargyrite contains arsenic and some Proustite contains antimony. When the percentage is considerable it is usually caused by a perceptible intergrowth of Pyrargyrite and Proustite."

"When the admixture is but slight and the crystals easily measurable, the presence of antimony in Proustite or of arsenic in Pyrargyrite produces no marked alteration in the rhombohedral angle."—*Groth, Zeit. f. Kryst.*, XV. Band., 132, 2 u. 3 heft.

Barytic Feldspars from Sjögrufvan, Sweden.

L. J. Igelström describes a red feldspar which he discovered in 1887, at Sjögrufvan, associated with yellow garnet, hematite, hausmannite, rhodonite, quartz, and *white barytic* feldspar. It is insoluble in acids.

The white barytic feldspar is pearly, transparent, and lamellar. It is insoluble in acids and fuses to a white globule.

The analyses are:

	Red feldspar.	*White feldspar.*
SiO_2,	61.90	54.15
Al_2O_3,	15.80	29.60
Feo, MnO,	5.00	
BaO,	9.58	1.26
MgO,	1.30	1.52
CaO,	0.40	1.
K_2O,Na_2O,	6.02	12.47
	100.00	100.00

—*Bull. Soc. Franc. Min.*, Tome XI., 263, Nov., 1888.

BULLETIN OF ALUMNI AND COLLEGE NEWS.

THERE is a general and very natural desire prevalent in the Alumni Association for news of what is taking place at the School of Mines and in the Association. It is, perhaps, the function of the QUARTERLY, the official organ of the Association, to convey this information to the graduates. Hitherto, the objection has been that the publication of family news in the regular columns of the magazine would lower the present high standing of the QUARTERLY in the professional world, as a technical and scientific magazine, and would certainly not interest the growing list of subscribers who have no association with the School of Mines, and who look upon the QUARTERLY simply as one of the technical magazines of the country.

Now, however, the plan has been suggested of printing in each QUARTERLY a bulletin of College and Alumni news which will be bound in only with those copies of the QUARTERLY sent to graduates. The editors especially request the co-operation of the graduates in securing notes suitable for such a bulletin.

The news of the school will be published under the headings of the various departments, and the chiefs of the departments have readily agreed to prepare for the bulletin such items as will be of interest to graduates.

The size of the bulletin will be limited simply by the news obtained, and its success will depend upon the degree in which the Association supports it.

The editors take this opportunity of stating that notes on professional work are always acceptable. A professional man who has not the time at his command for writing a lengthy article, may be able to prepare brief notes of professional work with little trouble, and by mailing such notes to the QUARTERLY for publication, will very greatly assist the editors in their work.

Letters are being sent by the editors personally to members of the Alumni. It has been thought well to print the following as a general appeal.

SCHOOL OF MINES, COLUMBIA COLLEGE, New York, —— 1889.

My Dear Sir: After several years of hard work, the editors of our School of Mines' QUARTERLY have succeeded in making that periodical pay its own way and a little more. For the present, then, the financial problem is out of the way; but we are confronted by a new difficulty, viz.: our graduates do not write enough for the QUARTERLY to keep us supplied with material.

The QUARTERLY is rapidly gaining an enviable position here and in Europe. Its articles are constantly quoted by leading scientific papers and periodicals. We hope that all our Alumni will take pride and pleasure in making the QUARTERLY a journal of very great importance. And to that end, I earnestly urge you to give us a helping hand by sending us some contribution in the way of a paper, notes, or a letter,

*

calling attention to matters you deem interesting or important. Will you not kindly charge yourself with one article for the year 1889?

Yours faithfully,

.....

OF BOARD OF EDITORS, SCHOOL OF MINES' QUARTERLY.

P.S.—Fifty reprints of the articles contributed by you will be furnished gratuitously.

In order to facilitate the selection and preparation of abstracts, the following card has been prepared, copies of which will be furnished to all willing to assist in the selection. The work of abstraction will be done by an organized corps of abstracters.

Editors of the School of Mines' QUARTERLY:

An article on.....

.....

by.....

in.....

should be abstracted for the QUARTERLY.

....

The editors advise that abstracts be chosen mainly from foreign periodicals or from the publications of learned societies.

An elaborate index of the first ten volumes is in course of preparation and will probably be issued during the summer. In order to partially cover the cost of printing, it will be sold at *twenty-five cents* per copy. It is requested that orders be sent at once.

NEWS OF THE SCHOOL.

DEPARTMENT OF MINERALOGY AND METALLURGY.—The Department has recently undertaken the work of collecting and arranging the "pamphlet literature" of mineralogy. This includes all articles of value which have appeared in pamphlet form, or as contributions to periodicals or in the transactions of societies. The collecting will be a work of time, but the collection should be of value to the science.

Mr. Robert Hoe presented to the Mineralogical Collection a gold specimen which was obtained by Dr. Egleston in California last summer, which is one of the most beautiful specimens that has been for sale for many years. It is composed of six octahedrons, the largest of which has faces one centimeter on the sides, and shows faces of the hex-octahedron, these are joined together and ended by a very large number of small octahedra joined together by their octahedral faces, so as to make a curved crystal 55. mm. long and 3. mm. wide. The faces are extremely well marked. It was found many years ago in California, in a small gulch leading out of Rich Gulch, which itself ends into the West Branch of Feather River about a mile south of Yankee Hill, in Butte County, and

has been kept as a priceless gem for many years. The gift of Mr. Hoe makes a real acquisition to the collection of minerals, and such interest on the part of persons outside of the school is very laudable and greatly to be desired.

Mr. Alfred Hoyt, of this city, has presented to the collection of minerals a large number of the most beautiful red crystals of Vanadinite from Yapavai County in Arizona, and also eight large crystals of Phenacite from Mt. Antero in Colorado, and also several beautiful specimens of Bertrandite upon Beryl. This is one of the additions of greatest beauty and money-value that has been made to the collection in many years. It is hoped that such interest will continue and that the beautiful American specimens will not pass through New York on their way to Europe without stopping in our collections.

The Gates Crusher Company of Chicago, have just presented a beautiful working model of their Gates crusher, which does such fine work at the Caledonia mill in Dakota, in crushing gold ores, where a single Gates crusher does in ten hours the work of a 60-stamp gold mill.

A vigorous effort has been made to fill the gaps in the collection of minerals, and the result is that during the year specimens of eighty-two species not previously represented, and seventy-five new varieties of represented species have been added to the collection. The species added are by classes as follows:

TELLURIUM.—Tellurite.

ANHYDROUS SILICATES.—Annite, Bodenite, Castellite, Cuspidine, Empholite, Ganomalite, Hydrotephroite, Szaboite, Zunyite, Zygadite.

HYDROUS SILICATES.—Achtaragdite, Anauxite, Bementite, Bertrandite, Bravaisite, Cataspilite, Ehrenbergite, Ekmannite, Elroquite, Epistilbite, Hydronephelite, Klipsteinite, Lillite, Melanosiderite, Pilinite, Roscoelite, Saspachite, Schuchardtite, Seebachite, Spadaite.

SODIUM.—Sulphohalite.

CALCIUM.—Dysanalyte, Monetite, Monite, Osteolite, Romeite, Staffelite, Titanomorphite.

ALUMINIUM.—Gearksutite, Löwigite, Peganite, Picroallumogene, Prosopite.

GLUCINUM.—Beryllonite.

CERIUM, LANTHANUM, DIDIMIUM.—Koppite, Korarfveite.

IRON.—Hielmite, Pseudobrookite.

MANGANESE.—Aimatolite, Allaktite, Alluaudite, Alurgite, Hetærolite, Lithiophorite, Manganosite, Talktriplite.

COBALT.—Bieberite.

LEAD.—Brackebuschite, Dechenite, Guitermanite, Plattnerite, Psittacinite.

ANTIMONY.—Arsenstibite.

URANIUM.—Annerödite, Cleveite, Johannite, Uranocircite.

COPPER.—Atelite, Atlasite, Chlorotile, Connellite, Julianite, Krönnkite, Mixite, Tallingite.

MERCURY.—Magnolite.

SILVER.—Argyrodite, Petzite.

GOLD.—Krennerite.

PLATINUM.—Sperrylite.

HYDROCARBONS.—Uintahite, Walchowite.

GEOLOGICAL DEPARTMENT.—During the past winter some very interesting and valuable material has been added to the geological collection of the School of Mines. It was before the best balanced collection, and the best adapted for geological instruction of any in this country, and contained by far the best representation of the mineral resources of the United States to be found anywhere. From its attractiveness, fulness and practical value it is a museum of which Columbia may well be proud, and it is much to be regretted that it should be so long left in its inaccessible position on the top floor of a six-story building, and only to be reached by an almost interminable flight of stairs. For the students it is not so bad, for they are doubtless benefited by the physical exercise this climbing of the hill of science entails; but for visitors from our city and country or from abroad, whose appreciation and good opinion is of real value and importance to Columbia, it is at present hidden and out of reach. Since a shaft has been provided in the construction of the building, the cost of fitting up an elevator would not be great, and it would pay the college many times over to make the upper floors of the building, where are located the Architectural, the Engineering and Geological Departments more accessible to the public.

The most noteworthy of recent addition to the geological museum are—

First. A splendid and unique collection of native silvers from the Silver King mine of Arizona, presented by the officers of the company, through the intervention of Mr. Arthur Macy, its superintendent and a graduate of the School of Mines. We venture to say that no such collection of native silvers is to be found in any other museum at home or abroad.

Second. A large and remarkably fine collection of ambers donated to the School of Mines by Mr. H. de Melli, one of the earlier students of the School. This contains examples of every variety of amber found on the shores of the Baltic, and representing nearly every phase which this protean substance assumes. It also includes several hundred cut and polished specimens containing insects and plants, and is by far the most valuable collection of its kind in this country. Not the least attractive part of this donation is the cabinet in which the collection is contained; this is a tall pyramidal structure of ebony inlaid with ivory, made by Pogliani of Milan, and is a real work of art.

Third. By far the most important additions made to the cabinet during the past winter are the large collections of fossil fishes from Ohio and fossil plants from the Laramie (Upper Cretaceous) of Colorado, purchased by Dr. Newberry. They are as yet only deposited in the museum, but it is hoped will be secured as a permament addition to its scientific treasures. The fossil fishes include the entire collection made through many years by Dr. William Clark of Berea, Ohio; and as he has removed to Kansas and left no one to continue his work, it is certain that nothing more will be obtained from that source for many years, if ever.

In this collection are two nearly complete sets of the bones of the greatest known Placoderm, *Titanichthys Clarkii*, N., of which the head was about five feet broad at the occiput, and the jaws three feet in length. These are the types from which the description of the species was written, and the only remains of this great fish yet discovered.

Other important elements in the collection are the unique type of the

new Placoderm, *Trachosteus*, of which the plate-armor was thickly set with acute bony papillæ a quarter of an inch in length, forming a surface like that of the rubber mats used by cashiers of business houses for the reception and delivery of coin. The eyes of this fish were surrounded by rings of bony sclerotic plates, like those of *Ichthyosaurus* and the raptorial birds; also large and small species of *Cladodus*, a Carboniferous shark, in an unprecedented condition of preservation. The sharks being cartilaginous fishes we usually find nothing left of their structure except their teeth, defensive fin-spines and dermal tubercles, but in these specimens the head and body are perfectly outlined, the jaws, teeth, eye-orbits and branchial arches all in position, and the fins showing not only their rays, but the web as perfectly as in life.

There are many other interesting things in this collection, but we will only mention a remarkable series of the bones of *Dinichthys intermedius*, N., of which there are complete crania, showing the inner and outer surfaces, jaws, teeth and all the body plates. Of these species only an under jaw is contained in any other collection, and that is in the museum of Oberlin College.

The fossil plants of the Laramie were collected by a man specially employed for that purpose, and include by far the best representation of the flora of the Upper Cretaceous yet obtained. These are now being drawn and described by Dr. Newberry for the completion of his Monograph of the Cretaceous Flora of North America which is to be published by the United States Geological Survey. The fossil fishes referred to above have all been figured and described as part of a Monograph of the Palæozoic Fishes of North America, which is now in the hands of the printer. The types of nearly all the species described in these monographs, as well as those included in Dr. Newberry's Monographs on the Triassic Fishes and the Flora of the Amboy Clays, are in our geological museum. Altogether they make it much richer in the remains of fossil plants and fossil fishes than any other museum on this continent.

ENGINEERING DEPARTMENT.—An important step has been taken by the trustees in establishing a post-graduate course in electrical engineering.

In the last issue of the QUARTERLY an article from the "Electrical World" was reprinted, setting forth most admirably the needs of such a course in New York City, and indicating the favorable reception which this movement on the part of the Faculty and the Trustees of Columbia College would receive from the members of the electrical engineering profession and the public.

The course was established as a post-graduate course in engineering, on the ground that a broad foundation in general engineering studies should first be laid, on which to base the special instruction required in the electrical course.

Since the issue of the last QUARTERLY, we have received a full report of the address delivered in January before the Institute of Electrical Engineers in London, by Sir Wm. Thompson, the highest living authority on electrical science, both in its theoretical and mathematical, and in its practical aspects.

If the Faculty and the Trustees had asked the advice of Sir Wm. Thompson, their action, already taken, could not have been more in accordance with the sentiments expressed by him in this notable address.

Alluding to the fact, that when the society which he was addressing was founded, only a few years ago, nothing like electrical engineering existed, he said:

"Electro-metallurgy and telegraphy were the two, and, I think, the only two, branches of practical science to which electricity had been applied. But since that time we have had a vast augmentation of the field. We have telephony; we have electric transmission of power. . . . We have now power electrically transmitted through factories to drive separate machines by separate dynamos. We have electric haulage, and electric tram-cars. We have the application of electricity to naval and military purposes; and last, not least, we have the application of electricity to electric lighting. . . . . But we must not forget that the province of the electrical engineer touches upon that of the civil engineer. . . . . Electrical engineers know well that they must, before all, be engineers. They must be engineers, and they must learn electricity. . . . . It is, I think, an important point this—that the electrical engineer, or the youth or the aspirant to that honorable profession, ought to learn mathematics and dynamics, after having obtained the elements of a good general education. He ought to learn mathematics and dynamics well. Then a good deal of chemistry and regular mechanical and civil engineering should all be learnt. . . . . I am perfectly sure that if the youth is qualified in other departments, the mere addition of electricity to the education of a competent engineer will not take so very long time as might be imagined, and that the merely educational part of the work will not be protracted unduly, by adding electricity to the branches learnt in general engineering."

Here is clearly outlined a post-graduate course in electrical engineering, by the very highest authority, for students who have already passed through a course in *general engineering*, and it is also quite distinctly implied that such a course must embrace not only the practical applications of electricity in engineering, but also mathematical instruction in the theory of electricity and its relation to energy or power.

Although the scheme of instruction has not been definitely determined by the Faculty and Trustees, its general scope will probably be comprised under the following headings:

The principles of electricity as applied to the arts and industries, in such a practical manner that the student shall be able not only to design, construct, test, and use the apparatus employed in these arts and industries, but that he shall obtain the facility for introducing such modifications as the special problems or conditions of his after occupations may require.

It is proposed to make this instruction personal, so that each student shall receive the knowledge of methods of manipulation peculiar to this branch of engineering, and as far as possible constructing and using the instruments, tools, machinery, etc., especially required.

It is proposed that the instruction shall cover the following subjects: Theory, laws, sources, measurement, and nature of electricity. Its properties as a physical agent in producing the phenomena of heat, light, magnetism, attraction, chemical action, and sensible energy or power.

Electro-dynamics, practically applied to the arts and industries. Instruction in practical work in designing and constructing, drawing specifications for and operating apparatus and plant for:

Electric transmission of power and electric motors.

Electric locomotives, or propulsion.
Economics of electric distribution.
Electric lighting.
Telegraphy overland and submarine, simple and multiplex.
Telephony and automatic signalling systems.
Special applications of electricity to mining.
Electro-metallurgy.
Stationary and movable torpedo systems and field telegraphy.
Testing and standardizing.
Methods of determining electric efficiency of apparatus.
Determinations of the constants of electric machinery.
Manufacture of instruments of precision.
Methods of determining the general electrical units.
Mathematical physics of electricity.
Mathematical relations of electricity, light, heat, magnetism and sensible energy.
Relation of the second law of thermodynamics to electrical energy.
Inductive determination of electrical laws, constants and electrical efficiencies.

The Engineering Department has recently had an opportunity to procure one of the celebrated Emery testing machines upon most favorable terms, and is trying to avail itself of it. This machine is of the same type as that of the 900,000 pounds machine owned by the U. S. government at the arsenal in Watertown, Mass., and embodies the same principles of marvelous sensitiveness and accuracy. It has a capacity of 150,000 pounds, and is adaptable for tension, compression and transverse tests. It is driven by a duplex plunger pump of special design, and occupies a floor-space 7 feet by 2 feet, and stands 15 feet high.

The cost of the machine new would be $7200, but the builders and present owners have offered it to the School for a less sum, and on specially easy terms as to payment. The offer has been accepted by the Board of Trustees contingently upon a raising by subscription from outside friends of the School of an initial sum of $2000. This amount is being now sought by the officers of the Department, and they will be glad of any help from alumni directly, or from friends whom they can interest.

It is almost unnecessary to speak of the advantage to the Department and to the School of the possession of such a piece of apparatus as this. The old machine of 1873, built by Fairbanks & Co., has been out of date for years, and since 1885, it has not been practicable or convenient to make use of it for purposes of instruction. Whereas, in all the constructive engineering of to-day, it is of paramount importance that a definite knowledge be at hand of the behavior of metals in such use, and no knowledge is as thorough or as satisfactory as that derived from actual experiment with a reliable apparatus in a working laboratory. If the School can secure this machine, and erect it suitably, the engineers will be able, and will be expected, to spend some time in actual use of the machine upon the usual engineering materials, as a feature of their regular course; and in graduate courses in engineering the field for its use is very wide.

To New York City, it will add distinction to have a piece of exact apparatus of this type, which in the nature of the case can only be held and operated by some institution, such as the College, and to be its pos-

sessor will be another addition to the prestige of the School and of the University of which it forms a part.

DEPARTMENT OF ARCHITECTURE. — In the paper read before the Alumni Association in May last, the head of this department said that, another year, the Trade Schools, established by Mr. Auchmuty in 67th street, might perhaps prove useful auxiliaries. The matter having been brought to the notice of the Trustees, they appropriated a sufficient sum of money in order to try the experiment, and since the middle of November the students of architecture of the third and fourth year's class, over thirty in number, have spent every Wednesday afternoon in the practical study of plumbing and masonry. The intention, of course, is not to make them skilful workmen, but to add object lessons to the theoretical instruction they get in 49th street. In the masonry class, however, they actually handle the bricks and mortar, and have already acquired skill enough to be interested in the exercise of it. One Saturday a volunteer party of half a dozen spent a chief part of the day in testing some of the curious processes described by M. Choisy in his *Art de Bâtir chez les Byzantins*, and by MM. Perrot and Chipiez in their volume upon Assyria. Following the indications of these writers, they succeeded, without difficulty, in building after the Assyrio-Byzantine manner a barrel vault with inclined courses and without centering, four feet wide and five or six feet long. Another year, if the experiment is continued, they will take up painting, plastering, etc.

SUPERINTENDENT'S DEPARTMENT.— The crowded condition of the buildings has caused various departments to make available all the space they can, and to sub-divide high rooms horizontally where possible or to extend vertically.

A floor has been placed on the book-cases in the herbarium, thus dividing that room into two stories. Book-cases and tables have been placed in the upper room, and thus a large amount of useless space has been made available for book storage and botanical work.

A floor has been placed on the book-cases in the transept of the library, on which are now tables for readers. Thus a large addition to the reading space of the library has been added without appreciably affecting its architectural beauty. An extension of this floor across the main reading-room resting on book-cases, may possibly be the ultimate method for securing the most economical storage of books in the future.

The Superintendent has proposed to the trustees that a floor be placed over the boilers in the boiler-house, and that the roof be raised; thus adding a second story, and that three new stories be placed over the vaults back of the boiler-house. The additional space thus secured will be devoted in the main to the new electrical engineering department, and to the extension of the mechanical engineering department, in which latter the new Emery testing machine will be placed.

Room will also be found in this extension in which to place some of the machinery of the repair department.

The erection of central electric lighting stations in the vicinity has enabled the college to abandon its isolated lighting plant. Arrangements are being made to light the School of Mines' buildings from the central station of the Manhattan Electric Company, at 81st street and avenue B. This company uses the Slattery system, with a high tension alternat-

ing current of 1000 volts, which is reduced at the building by a transformer to a 100 volt current

Arrangements are being made to light the library and Law School buildings from the central station of the Edison Company, at 39th street and Sixth Avenue. This current is low tension and continuous, but the system in the building will have to be changed from a "two" to a "three-wire" one.

The rapid introduction throughout the country of "oil fuel," under boilers in place of coal, has brought this question before the authorities of the college. With us, besides the usual economy incident to a reduction in labor, absence of ash cartage, etc., the large cellar of the Law School now used for coal storage will become available for other purposes.

THE ENGINEERING SOCIETY.—The Engineering Society has now an active membership of forty-five.

The officers for the college year, 1888–1889, are Edward F. Weekes, '89, President; T. M. St. John, '90, First Vice-President; F. W. Denton, '89, Second Vice-President; Frank M. Smith, '89, Secretary; George J. Hicks, '90, Treasurer; R. M. Raymond, '89, Quarterly Editor for the Society.

The programme for the year so far completed, including papers and public lectures, is as follows:

November 16th, 1888.—"Photography applied to Surveying."—A. C. Gildersleeve, '89. "Graduation of the Circles of Surveying Instruments."—A. Smith, '89. "Notes on the Field-Work of the U. S. Geological Survey."—F. M. Smith, '89.

December 4th, 1888.—"Description of a Crucible Steel Works in Jersey City."—F. W. Denton, '89.

December 14th, 1888.—Public Lecture by Dr. C. F. Chandler on "Electric Lighting."

January 11th, 1889.—"On the Mining of Thin Seams of Soft Coal."—R. F. Jopling, '89. "Notes on Blast-Furnace Practice."—F. A. Heinze, '89.

January 18th, 1889.—Public Lecture by Dr. R. W. Raymond on "The Present State of the Darwinian Controversy."

March 1st, 1889.—"Zinc Smelting,"—T. J. Jones, '90. "Occurrence and Working of Graphite Deposits."—F. C. Hooper, '90.

At a meeting to be held March 29th, a debate will take place on the question—"*Resolved*, That for a surface road, four miles in length, the cable system is preferable to the electric system as a means of transmission."

Mr. B. S. Church, Consulting Engineer of the Aqueduct, has consented to lecture before the Society on April 12th, on "The Relations Between an Engineer's Training and His Professional Practice."

F. M. SMITH, Secretary.

THE CHEMICAL SOCIETY.—The work of the year thus far has been:

October 22d—"The Aromatic Hydrocarbons," by G. A. Ferguson, '90.

November 5th—"On Germanium," by J. A. Deghuée '90.

December 3d—"The Antiseptic Value of Salicylic Acid," by W. H. Weekes, '89.

December 17th—"The Organic Compounds of Silicon," by B. C. Hinman, '90.

January 14th—"The Theory of Gravitation Applied to Chemism," by H. C. Parker, '90.

March 18th—A public lecture on "The Geological History of Man," by Prof. J. S. Newberry.

The Lecture Committee are arranging a lecture to be given by Dr. C. F. Chandler on "Spectrum Analysis," some time in April.

S. A. TUCKER, '91, Secretary.

NATURAL HISTORY SOCIETY.—This Society was organized on February 19th, 1889, for the purpose of encouraging the study of the natural sciences.

It is proposed to hold meetings at the college every two weeks during the scholastic year and also to meet in the field at least twice a month. The Society has visited the ship-canal cut at Kingsbridge, N. Y.; the sepentine out-crop at Hoboken, N. J.; the sandstone and trap at Fort Lee, N. J., and the Manhattan Iron Works, New York City.

Dr. Northrop read a paper on "Natural Sciences," and specimens from Manhattan Island and other places in the vicinity were exhibited.

The Society at present consists of 30 members. The officers are:

E. M. BLAKE, '90, President; H. RIES, '92, Secretary;
T. J. JONES, '90, Vice-President; L. R. CLARK, JR., '92, Treasurer.

H. RIES, *Secretary.*

AMATEUR PHOTOGRAPHIC SOCIETY.—The Fourth Annual Exhibition of the Society was held on February 14th and 15th, in the Chemical Museum. There were exhibited nearly five hundred prints taken by the active members of the society. Dr. Laudy, an honorary member, showed some very fine work in photo-micrography, among which was the photograph of the foot of a spider enlarged seventy-five diameters.

On the evening of February 14th a lantern exhibition was given of slides made by Dr. Laudy, J. H. Wainwright, W. M. Whitfield and C. W. Stoughton, members of the society. There were about sixty slides exhibited.

At the meeting of the society held March 15th, Mr. A. C. Gildersleeve gave a demonstration of the use of "Photography as Applied to Surveying." He showed the advantage of this method of surveying over the ordinary one, in that there is less liability of making errors in the field work.

HENRY R. TAYLOR, Secretary.

GRADUATE NOTES.

The annual meeting of the Association of the Alumni of the School of Mines, was held at the School of Mines, Columbia College, December, 27th, 1888.

The reports of the Treasurer and Secretary showed a balance to the credit of the Association of about $862, and that the affairs of the society generally were in a flourishing condition.

The President announced the election of the officers and managers for the year 1889 as follows:

OFFICERS.—*President:* F. A. Schermerhorn, '68; *First Vice-President:* S. A. Reed, '77; *Second Vice-President:* W. B. Potter, '69; *Treasurer:* J. K. Rees, '75; *Secretary:* P. de P. Ricketts, '71; *Assistant Secretary:* T. B. Stearns, '81.

MANAGERS.—*First Group:* W. A. Smith, '68; *Second Group:* F. R. Hutton, '76; *Third Group:* S. A. Reed, '77; *Fourth Group:* W. F. Morgan, '84.

In order to prevent in the future the great trouble which has been experienced each annual election, on account of the want of unanimity on the part of the members of the Association in the selection of a ticket, due to the plan of election

"*It was resolved*, That the President be authorized to appoint before March 1st, 1889, from the Association-at-large, a committee of five, to select and report to the Association, at its first meeting in the fall, nominations for officers and managers to be voted for at the next annual election."

The selections made by the committee are, of course, not binding, any member of the Association can make his own selection and vote accordingly.

The new Board of Managers met on January 18th, and organized.

In view of the amount of funds in the treasury and the condition of the Association, the Treasurer reported that he had deposited five hundred dollars ($500), to the account of the Association, in the Seamens' Bank for Savings. Hereafter, it is the intention of the management to deposit all life membership dues in some suitable savings institution, and to keep the same separate from the yearly dues.

The President appointed the following committees:

School of Mines' QUARTERLY Committee: A. J. Moses, J. K. Rees, J. L. Greenleaf, N. L. Britton. Committee on Conference: F. A. Schermerhorn, P. de P. Ricketts, S. A. Reed. Committee on Quarterly Meetings: Jno. H. Banks, I. H. Woolson, F. D. Sherman. Committee on Constitution and By-Laws: F. R. Hutton, W. Allen Smith, P. de P. Ricketts. Committee on Badges: P. de P. Ricketts, F. R. Hutton. Committee on Record Bureau: P. de P. Ricketts, J. K. Rees, A. J. Moses.

Of these, the Conference Committee has for its object, the consideration of all matters of mutual interest to both Alumni Associations.

The Committee on Constitution and By-Laws is now engaged in thoroughly revising the constitution, and it is hoped that the amended constitution will be presented at the next meeting of the Association for adoption, as the committee will report to the Board of Managers within the next week.

Among other important business transacted at this meeting, by the Board of Managers, it was resolved that the Secretary be authorized and directed to print the constitution of the Association, together with a full list of the graduates of the School and members of the Association, giving degrees, occupation and addresses, as a supplement to the School of Mines' QUARTERLY. In accordance with this resolution the Secretary has prepared a full list, but in view of the fact that the report of the Committee on Constitution and By-Laws will recommend some important changes, the publication of the constitution and list of members will be postponed until the July number of the QUARTERLY.

In the meantime, graduates and members of the Association are

earnestly requested to fill out the accompanying blank and to mail the same to the Secretary without delay. In filling out the blank, give the permanent address. It is almost impossible to keep track of members where the addresses are constantly changed.

We have to record the following deaths:

Class '75—D. A. Joy, E.M., June 15, '87. '79—G. H. Sheldon, E.M., April 8, '89. '76—Prof. H. C. Foote, C.E., August 24, '88. '82—O. V. Dougherty, Ph.B., April 7, '89.

Communications sent to the following graduates have been returned, marked as "not found:"

F. P. Bemis, E.M.; Chas. King Gracie, E.M.; C. B. Judd, E.M.; C. G. Slack, E.M.; J. T. Beard, E.M.; C. H. Doolittle, E.M.; C. P. Bleecker, E.M.

These gentlemen or any of their friends will confer a favor upon the Secretary of the Association by filling out the blank referred to and returning the same at once to

P. DE P. RICKETTS, Secretary,
Association of the Alumni of the School of Mines,
Columbia College, N. Y. City.

The following blanks may be torn out and mailed to the editors. Prompt attention will greatly assist the preparation of the list of addresses, and will also enable the editors to correctly judge the number of indexes to print.

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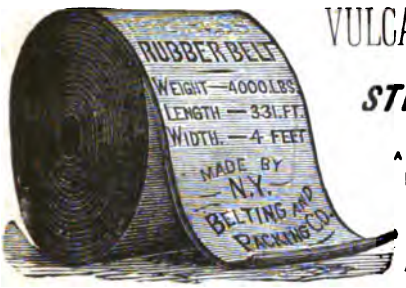

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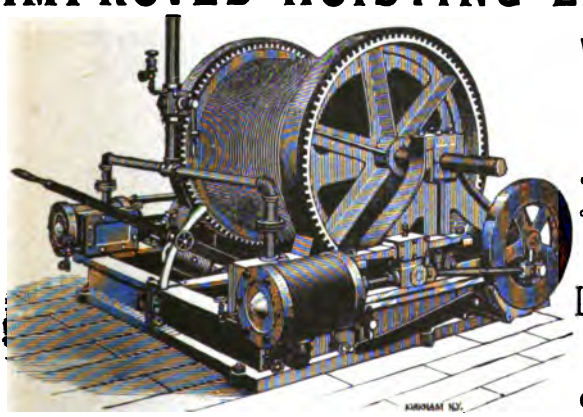

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SCHOOL OF MINES QUARTERLY.

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THE STREET PAVEMENTS OF NEW YORK.

BY PROFESSOR J. S. NEWBERRY.

SCARCELY any portion of the structure of a great city has more direct and important bearing upon the health and comfort of its citizens than the paving of its streets. The objects obtained by a good pavement are cleanliness, salubrity and facility of traction for wheeled vehicles. In all cities it has been found necessary to cover the roadway with stone or its equivalent, and innumerable experiments have been tried with materials of various kinds and with different methods of construction. The choice of materials has frequently been determined by the abundance or rarity in the vicinity of such as would better or worse serve the purpose, but the increase in the facilities of transportation have made it possible for all great cities to choose from various competing materials that which is best.

The Romans were the most skilful road builders of antiquity, and their skill in this department of engineering is attested by the fact that some of the Roman roads are still in use, two thousand years after their construction. The Romans took great pains with the road-bed, and in their great roads like the Appian Way, the surface was formed by a series of polygonal slabs of stone, fitted together with the greatest nicety. This was also the general character of the street pavements in cities, as may be seen in the streets of Naples, where the old methods of construction have

been followed, and in Pompeii, where the streets have recently been uncovered and show their precise condition at the time of the great eruption in the year 79, when the city was destroyed.

The objection to this kind of pavement is, that while easily kept clean and causing little jar to the springless chariots and carts which passed over them, the broad surfaces of the stones became smooth and almost polished by use, and must have been slippery, especially when wet. Now the roads of Europe are practically all macadamized, the roadway is hard and smooth enough, yet affords excellent foot-hold for horses, and is kept in repair by incessant watchfulness and light labor. In the larger cities, the streets have been in later years paved with blocks of stone; sometimes boulders from a stream-bed (cobble-stone pavement), and as an improvement upon that, cubical blocks fitted closely together.

Up to 1850, all the principal streets of Paris were paved with cubes of Fontainebleau sandstone, a style of pavement from its universality in Belgium, generally known as the Belgian. About the time of the *coup d'état*—largely because the paving stones were so convenient for the formation of barricades—on the boulevards and many of the principal streets a kind of asphaltic or macadamized roadway was substituted for the blocks of stone. In London, about the same time, blocks of wood began to be substituted for the stone pavements, and with various changes of style have continued in use to the present time.

Having had occasion in my lectures on Economic Geology to treat of the materials used for street paving, I ascertained as far as possible the results of experiments made on this subject in the principal American cities. I have also improved the opportunities afforded me in two recent visits to Europe to examine the pavements in the larger cities, and have compared the relative merits of the different methods and materials employed, in the hope of throwing some light on the problems presented to our people.

In order to make this report of the facts I have gathered as concise and useful as possible, I will refer briefly to the different kinds of pavement in use in Berlin, Brussels, Paris and London.

In Berlin, which is a comparatively new city, the pavements are stone and asphalt. The stone pavements are similar to those of Belgium, are well constructed and carefully kept in order, but they would be better if the blocks used were narrower. On the whole, they may be considered as fairly representing the excellencies and

defects of a pavement composed of this material. The asphalt pavement is generally made with the Seyssel asphalt, prepared much as in Paris and London, and exhibits the same excellencies; that is, it is clean, wholesome, silent and easy for horses, vehicles and their occupants. In Berlin is experienced the difficulty that must be encountered wherever stone and asphalt pavements are in use at the same time. That is, the shoes of the horses are worn smooth on the stones and are liable to slip on the asphalt in wet weather. This may be partially obviated by strewing the asphalt with sand, but where all the streets are paved with asphalt, horses properly shod are less liable to slip than on stone pavements.

In Paris, three kinds of pavement are in general use, viz.: asphalt, stone and wood. The wood pavement is a modification of our Nicholson, though more carefully laid and more durable, but like all wooden pavements becoming somewhat spongy with use and holding water.

In Brussels and other cities of Belgium, I saw only the Belgian pavement in use. This is composed of the Condroz grit or porphyry; the blocks are very carefully dressed, are of uniform size, and the pavement is much smoother than our stone pavement and more easily kept clean. In Liege and Bruges, the sidewalks are often composed of cubical blocks, but much smaller than those used for the roadway. These are so carefully put down that they are about as smooth as our brick pavements.

I noticed in the Belgian cities a device for tying the curbstones together, which struck me as a good one, viz.: in the end of one a shallow, angular furrow is cut, into which a projecting angle of the next stone is fitted, so that one cannot move without the other.

In London, I found four kinds of pavements in use, viz.: First, the *Macadam road*, of which a good example is seen in the broad street of the Thames Embankment; this is fairly smooth, durable and cheap, and affords a firm foot-hold to horses, but like all macadam pavements it is dusty in dry weather and muddy in wet. Second, *Granite pavement*, in which the blocks, never more than three inches wide, are carefully dressed, fitted closely together and bedded in concrete, so that the roadway is smoother than any stone pavement in America. The wear is comparatively small, and this is therefore the most economical of all pavements, but it is difficult to clean, since filth will gather in the joints, and it is the most noisy of all pavements. Third, *Wood pavements;* when I

was first in London, in 1850, most of the pavement was stone, but on several streets blocks of wood were laid; these were octagonal in form, six to eight inches in diameter and transversely grooved to afford foot-hold to horses. Of late years that style of pavement has been superseded by one of sawed rectangular blocks, similar in general character to the Nicholson pavement, but more carefully made and more durable. The blocks generally used are sawed from fir planks, are three inches thick, eight inches wide and six inches long; these are laid with a strip of felt between each row which causes a perceptible but narrow joint; sometimes the blocks are creosotized, sometimes not. On the whole the wooden pavement is satisfactory, being silent, smooth and only in rain slippery, but the blocks become spongy at top by use, hold water and form a sheet of decomposing vegetable fibre which must be insalubrious. Fourth, *Asphalt pavement;* this has of late years been growing in favor and is now the most popular style of pavement in use. It generally consists of a carefully prepared roadway covered with concrete and then with a sheet of asphaltic mastic, from Sicily or Switzerland, about two inches in thickness. In some instances the asphalt is mingled with gravel, more generally with sand. The excellencies of this pavement are its silence, its cleanliness and salubrity. It is washed or swept perfectly clean with little trouble, has no joints that are repositories of filth and is impervious to the passage of mephitic gases. It is also economical, wears as slowly as the stone pavements and only half as fast as the wood or macadam pavements; it is somewhat slippery when slightly wet, but long-continued observations have proved that horses fall as rarely on this as on stone pavement. The cost of the best asphalt pavement in London is from three to four dollars per square yard. It is very easily repaired, and the average annual cost of maintenance does not exceed ten cents per square yard. The wear of the surface is exceedingly slow; it is compressed by use, but the loss of material in an asphalt pavement in Paris is said to have been only 5 per cent. in sixteen years.

In New York, a greater variety of excellent materials for street pavements can be obtained and at a cheaper rate than in any other city in the world. Our "bluestone" is the best material known to me for flagging and curbing, and it exists in inexhaustible quantities in various localities on the banks of the Hudson, so that it can be floated to our wharves and supplied to the city at a less

cost than inferior stone can be obtained for in any of our own or foreign cities. It makes an ideal flagging, being very strong and durable and occurring in layers of two to six inches in thickness, of which the natural surfaces are so smooth that little dressing is required. For the very best flagging it is sawed or ground to a perfect surface, and yet this always has a grain which holds the foot in both wet and dry weather.

Granite and limestone make durable flagging, but they were so smooth as to become slippery and dangerous. The more granular and crystalline marbles supply material which is very handsome and does not become slippery, but it is more tender, is liable to crimp at the corners and is much less durable than the bluestone. Streets are rarely if ever paved with bluestone, but it would not make a bad pavement; it is very strong and tough, wears as well as any sandstone and does not become slippery. It has, at least, equal merit as paving material with the Condroz grit and the Fontainebleau sandstone, so much used in Europe, or the Medina sandstone, with which so many streets in our lake cities are paved.

Granite of excellent quality may be obtained in many localities near New York and perhaps better and cheaper in the highlands about West Point than from any other source. Here ledges of strong, handsome and durable granite come nearly to the water's edge and it can be put on barges and floated to New York at a price which must defy competition. From this granite as good pavement can be made as any other stone pavement in the world. A really good granite pavement has recently been laid down the whole length of Fifth Avenue, but this would have been better if the blocks had been thinner and the road-bed had been more carefully prepared.

The diabase of the Palisades has for street paving all the excellencies and defects of stone of this kind. It is remarkably tough and can therefore only with great labor be wrought into blocks of uniform shape and size. Indeed, this is never attempted; the stone is broken with the hammer into blocks that are approximately square or oblong, but they are of irregular sizes, cannot be fitted closely together and the upper surface is left lumpy and rough. It is evident that blocks of this kind have no other merit as paving stones than cheapness and durability. They are laid without cement on a road-bed always imperfectly prepared, and as a consequence sink irregularly, leaving elevations and depressions over

which rapid driving is well-nigh impossible. The unevenness of the street is increased and maintained by the frequency with which the pavement is torn up to get access to the gas or water pipes and is then carelessly replaced. The trap rock is capable of supplying material for a pavement well adapted to those portions of the city where the traffic is great and the vehicles are heavy, but with wear the stone becomes smooth and very slippery. A considerable improvement would be effected in our trap pavements by selecting a coarse-grained variety like that of Staten Island, which will not wear so smooth, dressing the blocks more carefully and to a uniform size, and never more than three inches wide.

Some years ago the Nicholson wood pavement was exceedingly popular in this country and some thousands of miles of it were laid down in our cities. Where carefully made and composed of good materials it was not only pleasant to drive over, but fairly durable, yet from the hasty manner in which it was generally laid and carelessness in the selection of materials, and most of all from the neglect of repairs, it soon deteriorated, lost favor and was replaced by something else. In the cities of the old world, wooden pavements have proved a success, and where carefully and skilfully laid they stand next to asphalt pavements in popular favor. The excellencies of wooden pavements are facility of construction, stillness, easy traction and a firm foot-hold to horses. Their defects are rapid deterioration from wear and decay, sponginess and insalubrity.

In London the wooden blocks are bedded in concrete and thus held firmly in position so that they wear evenly, and every defective block is removed as soon as discovered. With like care equally good wooden pavements can be made in this country, but it is a serious objection to them that they consume vast quantities of wood, which is becoming scarce and is all needed for other purposes.

The best of all pavements, as has been shown by experience in our own and foreign cities, is made of asphalt. When asphalt pavements first came into use in this country they were largely made with coal-tar and proved defective in many ways; afterward the methods and materials used in the Old World were imported and gave excellent results, but the use of the Sicilian or Swiss mastic, of which scarcely more than 10 per cent. is asphalt, made the pavement so expensive as to lead to efforts to utilize the Trinidad

asphalt,—which could be brought here cheaply,—mingling with it the requisite amount of sand, gravel and clay. About 1870, a series of experiments, made at the School of Mines by Mr. A. C. Campbell, demonstrated the possibility of making a mastic, with Trinidad asphalt as its cementing material, as strong, elastic and durable as that imported from Europe, but it was only after some years that this process was introduced and made a commercial success. The trial of asphalt as paving material at Washington, after many errors and failures, resulted in the general adoption of this covering for the streets, and made this the best paved city in the world. The example of Washington has been followed by other cities, especially those of the middle and western States, and the city of Buffalo has recently expended a million of dollars for asphalt pavements laid down by the Barber Asphalt Company.

The result of the experience of the last ten years has clearly shown that the pavement made with the Trinidad asphalt is equal to any in the world and superior to any other kind of pavement in use. Its excellencies, cleanliness, silence and salubrity, are so apparent that no argument is now needed to enforce them; to these may be added, and placed first in the list, *economy;* for it costs as little and lasts as long as any other good pavement, and is much less trying to horses, vehicles and human nerves. It is rapidly growing in favor and it is not too much to say that it is the pavement of the future and is destined in most localities to supersede all other kinds.

In a recent visit to Washington I found some of the streets in a bad condition. Even on Fourteenth street, in front of the Treasury building, the asphalt pavement is full of holes, and the condition of this great thoroughfare has led to an opinion which I found quite prevalent, that asphalt was only adapted to streets where the traffic was not great and the vehicles were light. This is a mistake, however. There is no street in America or elsewhere in the world that has as much traffic as Cheapside, London, and among the vehicles which pass through it are omnibuses, loaded with passengers inside and on top, carts of all descriptions, and, heaviest of all, the trucks of the great brewers with their enormous horses and tons of ale and porter. And yet Cheapside is paved with asphalt and is as smooth as a house-floor. The secret of its perfection is the thorough manner in which the pavement is laid and the incessant care given to it. In nothing is the axiom truer

than in the asphalt pavements, "that a stitch in time saves nine." The material has little hardness, and if from irregular settling of the road-bed or local violence a break occurs, the passing wheels rapidly shear off the sides of the hole, and it soon assumes formidable dimensions. In London this is prevented by constant watchfulness; persons are employed to traverse the street with a light repairing outfit, and wherever a defect is observed, this is patched at once, and so effectually that the spot cannot be distinguished. The contractors who lay the pavements agree to keep them in order for fifteen years at a price which does not average more than a few cents a square yard.

Our people seem to think that no pavement is a good one unless when once laid it will forever take care of itself; but there is no such pavement. Even our rough stone roadways would pay excellent interest on the expenditure necessary for constant inspection and repairs promptly made when needed.

One great difficulty stands in the way of the improvement of the pavements in the city of New York, and that is the frequency with which they are torn up for the purpose of laying new lines of gas, water or steam pipes, or for the repair of such pipes when broken or frozen. The depth to which frost penetrates the ground in our severe winters seems to make it necessary that our pavements, as at present laid, should be frequently torn up, and until more care is given to the removal and replacement of the pavement it is impossible that we should have smooth roadways. This evil could have been in a large degree obviated by sinking the pipes beyond the reach of the frost, but from the connections already made this would now be a matter of extreme difficulty, and it is even probable that we can never have a satisfactory system of paving until commodious subways shall be constructed to receive all the pipes and where they may be accessible without tearing up the streets. In the new streets opened in our rapidly growing cities the construction of such subways is possible and would prove not only a great convenience to the population, but a substantial economy. In the older streets the cost and inconvenience would be much greater, but the difficulty is not here insurmountable, and the benefits would far more than compensate for the cost.

AN APPARATUS FOR DETERMINING THE RELATIVE DEGREE OF COHESION OF A SEMI-LIQUID BODY.

BY H. C. BOWEN.

CEMENTS made, for paving purposes, in different parts of the country by different superintendents according to a prescribed formula, were found to possess different degrees of softness coarsely estimated in various ways, as by indentation by the finger-nail, by chewing a lump, by comparing elastic movements of similar thin plates of the cement, etc., all lacking that exactitude which is so necessary to enlightenment and progress.

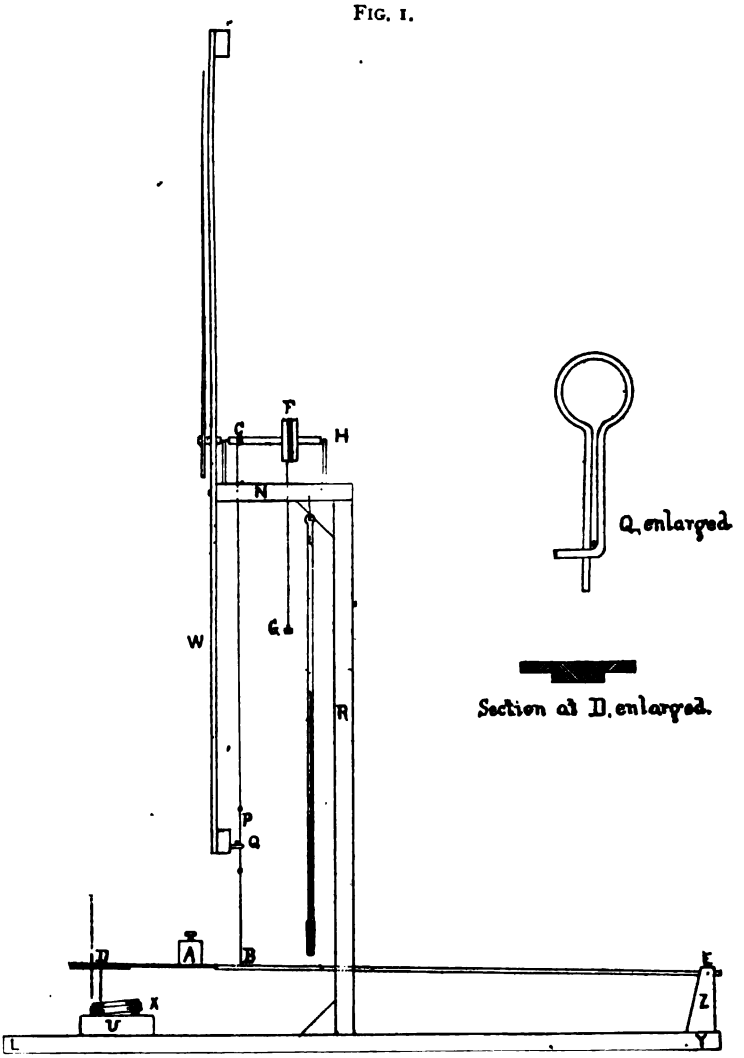
A paving cement should be both adherent and coherent to a degree which experience alone can determine. Hence the great need of being as exact, respecting this degree, as possible. Should a certain observed degree of softness of a cement be found associated with a certain good pavement, it follows, other things being equal, that a superintendent with such experience would be better able to perform continuous good work. An effort to bring this quality, softness, into exact measurement has resulted in the following apparatus, dependent on the following consideration:

A sharp polished needle, acting during a given short interval of time, under a given weight, and at a given temperature, penetrates a homogeneous, non-crystalline, semi-liquid body to a depth, apparently dependent chiefly on the degree of strength of cohesion of the body, or softness as commonly designated. The following apparatus is therefore constructed to measure the depth of penetration and thus to afford a number which shall represent the relative degree of softness of the substance tested.

The apparatus consists of a weight *A* (Fig. 1) acting upon a needle *D*, both on a lever arm having its axis at *E*. The movement of the arm *DE*, and thereby that of the needle *D*, is measured by the corresponding angular movement of the dial pointer over the dial *W*. The arm and the pointer are joined by a thread that is wound about the pointer axle *C*. This thread is held in place and in tension by the counter weight *G*. It was thought that the depth of penetration of the needle during a fixed short interval might be expressed in terms of one gram acting one second on the

needle, but judging from a few experiments it rather appears that the depth of penetration is not strictly in proportion to the weight. So it is deemed advisable to give the details of an apparatus that

FIG. 1.



has well served its purpose practically during the past six months. One using an apparatus of like dimensions can thus obtain results comparable with those of other persons. In case the apparatus should be built with other than the following dimensions, results

could still be made comparable by so building the apparatus that the same weight would be brought to act vertically on the needle during a second of time.

A (Fig. 1) is a 100-gram weight (cylinder) with eleven and a half twelfths of an inch diameter of base. The centre of this circle is eight and a half twelfths of an inch from *B*. From *B* to *D* is two and a quarter inches, from *B* to *E* it is fourteen and three-fourths inches. The axis *E*, is of needles resting in small openings in the thin metal side pieces *Z*. The diameter of *C* is 0.138 of an inch. The diameter of *F* is 1.459 inch. A rotation of 360° of the axis *H*, permits *D* to sink $\frac{1}{2}$ inch. *G* weighs $5\frac{3}{4}$ grams. Diameter of the dial *W*, is 18 inches. Height of *H* above the foot-piece *LY* is $17\frac{5}{8}$ inches. From *L* to the standard is $10\frac{1}{2}$ inches. From *A* to *E* it is convenient to use a wood piece $\frac{3}{8}$-inch thick and $1\frac{5}{12}$-inch wide, while from *A* to *D* $\frac{1}{6}$-inch thick wood does well. The piece holding *D* (the penetration needle) is $2\frac{1}{8}$ inches long, $\frac{2}{3}$-inch wide and $\frac{5}{12}$-inch thick, and the needle is so placed therein that when the needle-holding piece is in place as in the figure and at *M*, its distance from *A* and *B* will be as given above. The dial *W*, is mounted on a frame secured in position by a cross-piece that is screwed to the under side of *N*, with a perforation for the thread. *P* is a straight, rather coarse platinum wire about 3 inches long, and forms a part of the thread. The portion below *P* should be of the same material as the thread in order to insure flexibility to the lever *DE*. *R* is 3 inches wide and $\frac{3}{4}$-inch thick, provided with an opening, for the contraction in the arm *DE*. *Q* is a moderately strong pinch clamp with one tongue turned and driven firmly into the dial frame opposite *P*, with a portion of its loop also fastened into the frame. *U* is about $3\frac{1}{2}$ inches square and $\frac{3}{4}$-inch thick, with a $\frac{1}{12}$-inch thick strip tacked fast at about one inch from the back edge—thus giving a gentle incline to the cement surface in a tin box resting thereon. It also insures stability to the box when making tests and also facilitates removing *D* for cleaning. A pendulum, beating seconds, or better, a small clock, with a quarter-second dial and hand, is needed (since two experimenters get, in general, identical readings, it has not seemed necessary to complicate the apparatus with electrical attachments in order to overcome "personal errors.") The needle *D* is an ordinary sewing needle $1\frac{3}{4}$-inch long and approximately 0.8 mm. thick. Finer or somewhat coarser needles do not affect the re-

sults materially. The needle, the weight *A*, and the thread, and the movement of the arm *DE*, must be in the same vertical plane. Strong, fine, waxed silk sewing thread is used, depending most conveniently from the right side of the axle *C*, and from the left side of *F*.

In making tests, allow the substance, with mirror surface if possible, to remain near the bulb of a good sensitive thermometer (high penetration substances will show five to ten degrees on the dial to one on the mercury thermometer) that is hung close to the apparatus, for an hour or so. Then seek such a position of the tin box *X*, containing the substance to be tested, on *U*, that *X* will remain firm. Then with the right hand operating *Q*, and the left hand managing *DE*, by the help of a mirror reflecting light upon the cement mirror, the needle point can be placed at about $\frac{1}{2}$ mm. from the surface and near to the front of the substance being tested. Then by help of the reflected light the needle can be brought exactly to the surface by gently bringing *U*, with *X* thereon, forward. Take the dial reading and release *Q* at the exact commencement of the second and as punctually close it at the exact end of the second. The difference of the readings is the penetration number.

Withdraw the needle slowly. With substances that are cohesive and more or less adhesive, one of the following conditions will be noticed (Fig. 2). The common horizontal line represents the

FIG. 2.

surface of the substance being tested. In *a*, *b*, *c*, the needle comes away little or not at all smeared, while in *d*, a lump of matter will cling to it. These have been rated, *a*, not adhesive; *b*, rather adhesive; *c*, quite adhesive; *d*, very adhesive. Withdraw *D* from *DE* and clean it with soft paper, and by puncturing a closely rolled towel. Return it to its place and bring *U* with *X* a little forward, and by means of *Q*, and left hand at *D*, place the pointer 10° or 15° further back on the dial than that at the previous setting.

Then bring the needle point to the surface as before. By this means work can be done rapidly, and a row of tests across the sample is usually sufficient. 25° C. (= 77° F.) has been found, all things considered, the best temperature for the tests. A small room with northern exposure, provided with enough gas burners, is very suitable, and no difficulty will be found in securing and maintaining the temperature named.

The arm *DE*, is made long, in order that the needle-point movement should describe a line as nearly approaching the tangent as possible, and thereby to a corresponding extent to counteract the pressure which otherwise would be exerted upon the back of the needle.

The following columns *A*, *B*, *C*, exhibit practical results on consecutive work of each of three superintendents during about one week. Each result is the average of six to ten tests. If tests run close then but few of them are made, while if they vary much, ten or more tests are made and averaged. An instance is also given of ten tests on the same sample. The irregularity there noticed is presumed to be largely due to non-homogeneity in the substance, though there are a few phenomena which do not give strength to this view.

PRACTICAL RESULTS.

Upon Known Substances.	Upon One Sample.	Upon Consecutive Samples of Different Makers.		
		A.	B.	C.
Paraffine, ... 49	62.5	73	95	94
Coal Tar Pitch, ... 58	62.5	96	96	80
	63.0	89	98	107
Beeswax, ... 48	64.0	95	98	111
White Beeswax, ... 36	62.0	82	100	105
	60.5	66	99	118
Chinese Wax, ... 69	63.0	88	98	97
Tallow, ... 210	62.0	106	101	85
	64.0	82	95	102
	65.0	88	98	95
	Average, 62.8			

It is easily perceived that the work of *A* is irregular, while that of *C* approaches the regularity that is so marked a characteristic of *B*. These differences being brought to sight, suggest investigation regarding the causes, and thus aid in bringing the work of *A* into accord with *B*.

A great number of tests were made with different spindles in

place of *D*. (Fig. 1.) A cylinder (about 2 mm. diam.) was used with square end, with conical end, with a disc having edges round, and also sharp like a knife edge, and lastly with a terminal knob, thus thinking to make tests more successful without breaking the surface of the substance. Results were so varying with each of these spindles, that they were deemed at the time useless for practical work. Intervals of various lengths of time were used also with these spindles, but without success, nor did better fortune attend efforts at using definite depths of penetration and noting the number of seconds required.

In the first column the penetration number of a few well-known substances is given in order to convey an idea of the signification of the numbers as regards softness.

The best results have been obtained with a moderately fine needle, not differing much from that described above, acting during an interval of one second. But even with the needle acting during one second, tests will often differ from each other four and five degrees, even when the substance is homogeneous. Doubtless the "personal error" at the beginning of the second, when the fall is necessarily rapid, is a principal cause.

The exact study of the different phenomena observed in the use of the apparatus is at present too incomplete to permit presenting results at this time.

SCHOOL OF MINES, NEW YORK, JUNE 6, 1889.

A DISCUSSION OF CERTAIN POINTS IN CONNECTION WITH SEWERAGE AND DRAINAGE IN THE VILLAGE OF NEW BRIGHTON, STATEN ISLAND.

BY ARTHUR HOLLICK, PH.B.

IN the last number of the QUARTERLY the subject of sewerage and drainage for the village of New Brighton, Staten Island, was outlined in a general way, incidentally leading to a discussion of the relative claims of the combined and separate systems. The object of the present article is to present in somewhat greater detail, several facts and points which were there merely hinted at or else broadly stated.

Since the former article was prepared, a committee from the Board of Trustees and one from the Board of Health met and discussed plans for the improvement of the sanitary condition of the village. The Board of Health were in favor of a commission and an heroic treatment of the matter. The Trustees were more conservative, however, and finally a bill was drafted in the form of amendments to the village charter, giving the Trustees power to condemn the right of way for sewers and drains wherever deemed advisable, and also providing that sewers may be constructed wherever the Board of Health declares them to be necessary for the preservation of the public health. While this was not such a radical measure as some desired, yet it was recognized as a step in the right direction, and was accordingly pushed to a successful issue in the Legislature, and is now a law.

The first sewers in the village were constructed in 1875; they were upon the combined system, and apparently served as such excellent examples that none have since been attempted upon similar plans. The first of these was through portions of Central avenue and Arietta street, and was petitioned for ostensibly as a sewer to be constructed through these streets "of sufficient capacity to carry off the water which drains into them." As a matter of fact, the real object of this so-called sewer was to divert a brook from its natural course, and this it successfully accomplished. The outlet of the brook was at a point where a slip had been dredged out, and the quantity of silt carried down by the brook was a constant source of trouble. It would hardly do to state all this in public records, hence the petition for a sewer, with which no direct house connection was made until about ten years afterward! The first *bona fide* combined sewer was constructed shortly afterwards through Clinton avenue, and it has amply fulfilled its mission as an educator, even if it has failed to do all that was expected of it as a sewer.* Matters seemed to come to a standstill after

* This sewer is constructed partly of brick and partly of 16-inch pipe, circular in cross sections throughout, and cost $8767.99, or about $3.90 per lineal foot. The average annual outlay for keeping it in proper condition has been about $100.00, and constant complaints are made in regard to foul odors emanating from it through street culverts. Compare with this the La Fayette avenue sewer, constructed of 5-in. vitrified pipe, which cost only $2767.99, although a trifle greater in length, which has cost nothing for maintenance, and which is as clean and free from nuisance to-day as when first laid.

this experience, until the year 1882, when the subject of small pipe sewers began to be agitated, and from that time forth, the village practically committed itself to the separate system, presumably for sanitary reasons only. Interested parties took it up vigorously, and the Davis avenue and La Fayette avenue sewers were laid. These gave such universal satisfaction that others were laid, and it is safe to say that only pipe-sewers will hereafter be permitted. This is a matter for sincere congratulation, so far as it goes, but unfortunately there is a feeling of distrust in regard to the ultimate intentions of certain parties claiming an interest in the so-called patents of Mr. George E. Waring, Jr., which include almost every detail of the work thus far accomplished in the village. Up to the present time, although several miles of small pipe-sewers have been laid, with automatic flush-tanks, etc., complete, and necessarily including other details of the patents, yet there is apparently no record on file of any claim for royalty ever having been made, or of any tribute having been paid to any one. Nevertheless, this apprehension is fostered, let us hope inadvertently and with the best intentions, by the persistence with which the attempt is always made to insert the name of Mr. Waring into every petition which is started for a sewer. Latterly, however, the people have become more or less alive to the fact that small pipe-sewers may be laid without the necessity of including the name of Mr. Waring, or any other person in the petitions, and there is no doubt that a firm stand would be taken against any pretense of enforcing claims on account of any patent or other alleged rights, just as has been done in other places. In more than one instance parties have refused to sign a petition presented to them unless the name of Mr. Waring was expunged. In other cases, unfortunately, the petitioners allowed their names to be used for sewers to be constructed under the "separate or Waring system," thus giving a quasi official sanction to it. Under these circumstances, it seems as though a critical and impartial examination of Mr. Waring's patents and the claims covered by them might well be discussed here, especially so far as the sanitary aspects of the subject are concerned.

The first patent granted to Mr. Waring is dated January 18, 1881, and states that: "The invention consists in providing a system of sewerage for the collection and removal of house-waste and foul waters, and their removal—independent of the removal of storm-water—through one main pipe to each system; providing

flushing-tanks at the ends of the branch-pipes, connecting the house-drains with the sewers by a branch as large at their junction as the sewer, and ventilating the system by providing open-gratings to admit air to the sewer, *and connecting house-drains with the sewer without the use of traps, extending the same above the house,** so as to insure a continuous circulation of air through all parts of the sewer.

"The invention further consists in laying into the same trench with the sewer-pipe, a drain-pipe, and in the peculiar and novel devices more fully set forth hereinafter, by which the construction of the system is facilitated, and its continuous and efficient operation secured." This part is certainly plainly stated, and should be readily understood without quoting anything further. The following part, however, referring to drainage, needs to be quoted in full in order to be appreciated: "Drain-pipes are usually laid with a ring surrounding the abutting ends of the pipes. This ring serves to hold the pipes in line until the trench is filled in and the soil is settled around the pipe. This joint increases the cost of the drain-pipe without adding to its durability or usefulness, and it is desirable to dispense with the same. In Figs. 10 and 11, my improved joint is shown. B B are two lengths of drain-pipe, and X is *a strip of stout paper wrapped around the joint.** This paper is sufficient to retain the joint in place until the drain-pipe is securely laid. It is much cheaper than the older sleeve, and as in time it will be dissolved by the moisture, the open joint of the porous pipe becomes available for drainage." The question of the validity of a patent founded upon such "inventions" need not concern us—that is something for the lawyers to decide—but the sanitary aspects of the same are fair subjects for our criticism, and it should be the duty of every one conversant with any facts in connection with the practical working of the system, or the principles involved in it, to make them known, with such bearings as they may have upon the public health. In the first place, the danger from the untrapped house-connection, was so universally understood and recognized, that protests and criticisms poured in from all directions. Almost every sanitarian of note condemned it, boards of health prohibited it, and all people of intelligence refused to allow their houses to be connected in that way. I take it for

* The italics are mine.—A. H.

granted that this is so well known at the present time that reference to any authority or particular case is not necessary. It is the opinion of several who are competent to express themselves upon the subject, and who are generally accepted as authority in such matters, that more than one case of fatal illness in the village of New Brighton, and one series of cases almost amounting to an epidemic, can be clearly traced to the untrapped house connections along the line of one of the "Waring" sewers. The facts were so conclusive that the Board of Health was forced to recognize their significance, and in consequence, the following resolution was adopted, which may be found in the minutes of the Board for August 23, 1887.

"That all house drainage hereafter connected with the public sewers of the village be provided with a proper running trap, situated at a point convenient of access, and having a hand-hole for cleaning, fitted with a gas-tight cover. An air inlet pipe for the house drain of adequate size is required to be connected just inside the running trap and opening at some point not in the immediate vicinity of a door, window, or cold air box for a furnace. Where necessary, vent-pipes will also be required on the outside of the running traps."

It may seem strange, but it is the fact that considerable opposition was encountered in trying to enforce this resolution in spite of the almost vital necessity for it. There is no doubt, however, that most of this was due to interested parties, who imagined that it was intended as a blow at Mr. Waring and his system, probably not being aware that Mr. Waring had long before been forced to yield to the overwhelming evidence, and secure a modification of his original patent in order to be in line with the sanitary progress of the day. Such is the fact, however, and on June 5, 1883, a second patent was obtained, which is worthy of the most careful reading from beginning to end. It states that "The improvement hereinafter described has reference to and is predicated upon the improvement in sewering and draining cities set forth in the Letters Patent, No. 236,740, dated January 18, 1881, heretofore granted me, and to which reference may be had.

"The object of the present improvement is to simplify the system described in said patent without lessening the efficiency of the system. . . . . I have . . . . ascertained from experiment that while it is desirable and proper that the house connections with the

sewer should extend through to the house top without traps between the house and the sewer, *it is not indispensably necessary for the practical and efficient working of my system of sewering that the house connections should extend through the roof of the house, nor that trap connections between the house-pipes and the street sewer be omitted.*"* The calm manner in which the unventilated house drain and soil-pipe is referred to may strike the sanitarian as being even more reprehensible than the previous attempt to enforce the omission of the house-trap. What then will be said in excuse of the following words:

"In cases where an open soil-pipe is not carried through the roof of the house, and where the house drain is separated from the sewer by an intervening trap, the influence of the volume of water discharged from the flush-tanks and flowing through the sewer-pipes is so great that a very effective ventilation of the sewer is secured, for the reason that an ordinary house-trap affords so little resistance to air-pressure that *in the absence of an open ventilated soil-pipe passing through the roof, the water in the traps will yield and permit the passage of air through the traps by the process known as the 'siphonage of traps,' and consequently there will be a considerable amount of air which will be sucked into the house-pipes through the bowl and closet traps, where there is a system of small sewers copiously flushed by flush-tanks at the heads of the branches, as contemplated by my system.*"*

If these words were not definitely known to be the statement of a fact by an eminent sanitarian of the present day, we might imagine ourselves to be reading an account of house drainage in the Middle Ages. To all appearances it is a matter of the utmost indifference that the traps of the fixtures in the houses are siphoned, their water seals destroyed, and free access of sewer air to the houses permitted. There is not a word of warning or a hint of danger given, and certainly where a person with the popular reputation of the patentee fails to sound a note of alarm, and even speaks as though the arrangement receives his sanction, it is not likely that the average person will look for danger. He would be more likely, in fact, to accept without question everything for which he knew Mr. Waring to be responsible. It therefore becomes the duty of all who are conversant with the facts to point out the dangers and indicate the

* The italics are mine.—A. H.

proper precautions to be taken wherever the small pipe system is in use. Fortunately, most plumbers understand the necessity for a proper ventilation of all soil, waste, and drain pipes, and it is a rare matter to find a house built in any enlightened community, within the past ten years, where this is not, at least in a measure, attended to. The chief danger is to be found where old houses are connected with the public sewers. Local boards of health should adopt and enforce rigid rules whenever such connections are made, and none should be permitted unless the house pipes are ventilated, all fixtures trapped, a main trap provided on the house drain, and a fresh air inlet connected just inside this trap. Should it be deemed advisable, in order to maintain the seal of the house trap, or to provide a vent for the public sewer, a cast-iron pipe could be run from the outside of the trap to some point where no danger could ensue from the escaping sewer air, preferably above the roof of the house. But, to return to the wording of Mr. Waring's last patent: "While my system comprehends the exclusion of storm-water from the sewer-pipes, it is to be understood that I mean by the statement that storm-water is to be excluded, that the system of pipes is not to be constructed as a whole with reference to taking care of storm-water draining from the streets or from the roofs of houses, *and although in individual cases the connection of a rain-water leader with the sewer by a householder may be made, or an occasional instance of the connection of a street culvert with the sewer may occur, the same would not change the character of my system.**

"While my system comprehends the exclusion of storm-water from the sewers, and is not adapted to receive such water from any large proportion of street or roof surface, *it will not be injured or rendered inoperative by the fact that the authorities of the town may fail to enforce the rule of complete exclusion,** so that, for instance, a householder may surreptitiously connect a roof leader, etc. . . . .

"There is also included in this system the combination with the sewer, when it is laid through wet ground, of a porous sub-soil drain, made of drainage tiles with permeable joints, substantially as shown in my said former patent; but the improvement herein exhibited is *the method of protecting the joints against the admission of earth by wrapping them with a woven or felted fabric.**

"In my former patent the joint is protected by a strip of paper

* The italics are mine.—A. H.

wrapped around the pipe at the joint. A better result may be obtained *by wrapping around the joint a piece of muslin or similar fabric*,* which is much stronger and more durable than paper."

It will naturally be asked, after reading this, whether any attempt at sewering and draining can be made without infringing upon these patents. Apparently, everything which has ever been tried in the past, or is likely to be tried in the future, is included, besides certain contingencies which may occur. They comprehend pipe-sewers of all sizes, combined with some method of automatic flushing, omitting or including any particular method of ventilation, admitting or excluding storm-water in limited quantity, omitting or including traps upon house connections, and omitting or including open soil and waste-pipes. Fortunately, sub-soil drainage may be indulged in by any one who may wish to do so, and no law-suit need be feared, provided, of course, that the joints of the pipes are not wrapped with paper, muslin, or similar fabric. In view, however, of the experience which some misguided individuals have had with paper and muslin joints, it is pretty safe to say that this part of the patent will never be in danger of infringement.

There are many other details of considerable interest in connection with the subject, and much that is yet to be learned by experiment and experience. According to the wording of the patents, the connection between the sewer and house drain must be a funnel-shaped **Y**, four inches in diameter at the house end, and of the same diameter as the sewer, whatever it may be, at the sewer end of the **Y**. This is stated to be in order "that their flow may be delivered at the bottom of the sewer, and so that they may withdraw the air from its crown." As a matter of fact, sewers which are supposed to be constructed upon the Waring system in the village of New Brighton *are provided with* **T** *branch connections on the top of the sewer*. This arrangement practically raises the level of the sewer by more than the amount of its own diameter, making it sometimes impossible for house drains having a limited fall to connect with it. This has occurred more than once, and in one instance I am credibly informed the result was that an exasperated property owner surreptitiously broke a hole in the side of the sewer pipe in order that connection could be made with it, the **T** branch on the top being at too high a level. As there is no sanction in any of

* The italics are mine.—A. H.

Mr. Waring's patents for such connections, I was curious to ascertain the reasons for their use, and was kindly furnished with the following answer to my question by the village engineer: "They make a much better line, are easier to lay, are less liable to cause stoppages, do not cause eddies in the flushing current, do not present corners where solids can lodge, making thereby a cleaner line, and afford the most convenient hand-holes for getting at possible obstructions, without cutting the pipe or interfering in any way with the flow of sewage. Y's are never used except when we find it necessary owing to lack of fall—then I cut the pipe and put in a slant myself. I have had occasion to do this twice only."

Were these advantages discovered by the village engineer, or may we shortly expect another patent from Mr. Waring covering this point?

If it were not a very serious matter, it would be almost amusing to read the following ingenuous passage from Mr. Waring's first patent: "With the system of small pipes now described the flushing would be so constant and complete, and the amount of ventilation furnished, as compared with the volume of air to be changed, would be so great, that what is popularly known as 'sewer gas' would never exist in any part of the public drains. Even the gases produced in the traps and pipes of the house itself would be amply rectified, diluted, and removed by the constant movement of air through the latter." It is probably upon this theory that the "siphonage of traps" is regarded with so much indifference, or it may be necessary, in order to preserve patent rights, that statements must be made which it is never intended shall be incorporated into actual practice. For the sake of all who have been instrumental in pushing the "Waring system" ahead at all hazards, let us hope that this is the explanation of the case, and that Mr. Waring is not responsible for the many blunders which are credited to him, and for which his own words are certainly to blame.

* * * * * *

Since writing the above, several facts of importance have come to my attention which have a direct bearing upon this discussion. Thus, I found upon file in the office of the village clerk a letter from Mr. H. L. Horton, addressed to the Trustees, dated July 10, 1883, in which he states that the total cost of constructing the sewer, now known as the Horton sewer, from Fort Hill to the Arietta street sewer, was $3587.99, which sum included "all labor,

material, royalties, etc." No mention is made in regard to whom the royalties were paid, or their amount, but as the sewer is constructed of small pipe, with flush-tanks, etc., it is to be presumed that Mr. Waring, or some one representing him, received the money. Another letter, dated July 24, 1883, from Mr. E. J. Thompson, attorney, calls attention to the rights of Mr. C. T. Barrett in all sewers laid under the Waring system in this region, from which it was inferred that Mr. Barrett was Mr. Waring's accredited representative in the village of New Brighton. This fact was generally understood, although nothing of a documentary nature more tangible than the above could be obtained; for, as long as a few favored individuals secured the contracts for laying sewers, nothing was ever heard of royalties being either claimed or paid. Within the past few weeks, however, a contract was executed between the village and Mr. Dennis Donovan for the construction of a pipe sewer in Jersey street, and the work of construction was promptly begun. The specifications call for 700 feet of 10-inch pipe, and 3350 feet of 8-inch pipe. 40 4-inch x 10-inch and 150 4-inch x 8-inch double T's are required for house connections, and two automatic flush tanks, with Field's improved siphon, are to be attached. Immediately upon the commencement of the work, Mr. Donovan was approached by Mr. Barrett, who endeavored to dissuade him from continuing the work, and threatened to sue him for royalty in the sum of $440, or at the rate of about 10 cents per foot of sewer to be laid, in case he completed the work and complied with the provisions of his contract. Naturally, no attention was paid to this demand and threat, so shortly afterwards the following letter was received:

BOSTON, June 7, 1889.

DENNIS DONOVAN, ESQ.

My Dear Sir: I am instructed by the owner of Letters Patent on Waring's sewerage system to inform you that the system of sewers about to be constructed by you in the village of New Brighton, Richmond County, N. Y., is an infringement of said Letters Patent, and that any infringement of these Letters Patent will be prosecuted to the full extent of the law.

Yours very truly,

GEORGE O. G. COALE.

P.S.—Further information can be had at the above address.

It is needless to add that Mr. Donovan is proceeding with his contract, and the only fear experienced by his advisers and others

who are disinterestedly conversant with the facts, is that the threats will never be carried any further, and that the issue will never be brought into court, but will follow in the wake of the numerous other abortive attempts to enforce Mr. Waring's absurd claims. Lest the tone of these remarks, and the general treatment of the discussion, might be considered as merely the expression of personal opinion on my part, I would respectfully refer to the treatment which the subject has received, within the past six months, at the hands of parties whose authority will not be questioned, in the columns of the *Engineering and Building Record and Sanitary Engineer*. In particular, I would call attention to a communication from Mr. Andrew Rosewater, of Omaha, Nebraska, which is published in the issue of May 4, 1889. Perhaps I cannot do better, in closing, than to quote the following words from his communication:

"The publication of Mr. Hartford's report on the lamentable condition of the Memphis sewerage, and Colonel Waring's subsequent attempts at explanation of the defective features which, until now, he has extolled as possessing superior merit, added to Colonel Waring's persistent misrepresentation of the sewerage of other cities, and his claims to originality of conception of the separate sewerage system . . . . certainly demands attention at the hands of every engineer who takes any interest in sanitary science, and particularly those having such work in charge." [Then follows a critical discussion of the patents, which should be read by all who wish to be well informed on the subject.] After this he uses the following words and asks the question, which I have often asked myself: "In view of this, the great problem of the sanitary engineer of this period is, WHAT CONSTITUTES THE WARING SYSTEM?" Perhaps as good an answer as any was the one received by me, not many days since, from the lips of a well-known sanitarian, "THE WHOLE EARTH!"

GRAPHITIC ANTHRACITE IN THE PARKER MINE, WOOD RIVER, IDAHO.

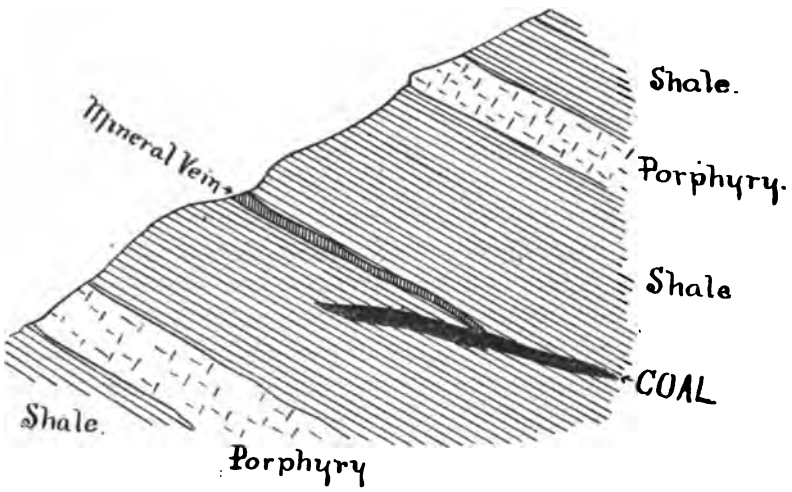
BY WALTER P. JENNEY, E.M., PH.D.

ABOUT four miles east of the town of Ketchum, the terminus of a branch of the Oregon Short Line Railroad, is situated the property of the Parker Mining Company, a mine noted in the past for a brilliant but short-lived period of productiveness, for ore of remarkable richness and purity, for a singular association of minerals and for the occurrence, in connection with the silver ores, of large deposits of graphitic anthracite.

The geological formation of the district consists of impure limestones and calcareous shales, with intrusions of andesite as dykes more or less conformable to the stratification. The shales carry so much carbon as to be black in color and the waste from the workings resembles that from a coal mine. Nowhere in the vicinity have any fossils been found whereby the age of these rocks might be determined, but from structural resemblances and position they are supposed to be Cambrian or Silurian.

The vein of the Parker Mine is a fissure very nearly conformable to the dip and strike of the enclosing shales, but in places cutting the strata with slickensided walls. The dip averages 30 degrees from the horizontal, being somewhat steeper than that of the shales. Above and below the vein, at distances of about 300 feet, are dykes of andesite 50 to 100 feet in thickness, coursing through the mountain substantially parallel to the vein; these intrusions are doubtless the cause of the fissure and of the mineral deposits with which it is filled. The gangue of the Parker vein is a singular intermixture of white quartz with coarsely crystalline calcspar; the minerals are zincblende and iron pyrites carrying little or no silver, and galena and polybasite forming the ore, and yielding by carload shipments 175 to 675 ounces of silver per ton, with 45 to 70 per cent. lead. The past production of the mine has been about 300,000 ounces of silver and 1,000,000 pounds of lead, with a gross value of $350,000; all extracted from an ore-channel 100 feet in width, extending from the surface to a depth of 600 feet on the slope of the vein, at which point the ore gave out and the fissure below was filled with soft black clay.

In prospecting on the course of the ore-channel below the point where the ore ceased, a deposit of graphitic anthracite was encountered, filling a fissure, lying almost flat. This body of coal varied in thickness from two to six feet, and as the explorations progressed an area more than 200 feet square, with an average thickness of three feet, was developed. The coal was solid and massive, requiring blasting to remove it; in appearance it resembled anthracite which had been subjected to crushing and compression until all traces of structure were destroyed. The coal was full of slips and slickensided surfaces and the walls of the fissure were also



polished in places. Small irregular veins of quartz intersected the coal in places and wound through the mass, but for the most part it was uniform in quality and appearance and free from any contaminating material. The following analysis of an average sample of this coal was made at the laboratory of the St. Louis Sampling and Testing Works:

Analysis.

	Per cent.
Moisture,	1.72
Volatile matter,	7.86
Fixed carbon,	81.61
Ash	8.81
	100.00

	Per cent.
Sulphur,	0.79
Carbon,	82.18
Hydrogen,	4.10
Oxygen and Nitrogen,	3.09
Ash and loss,	9.84
	100.00

The above analysis shows that this substance corresponds in composition to coke; but its occurrence in irregular fissures precludes any view of the origin being from the alteration of a bed of pre-existing coal. The probable origin of the deposit was as follows: The dykes of andesite, enclosing between them the belt of slate 600 feet in thickness, rich in carbon derived from organic matter, have held the included rock as in a retort, and the asphalt distilled by the heat of the intrusion filled the fissure and subsequently was coked by further heat, crushed and consolidated by pressure due to movements of the enclosing rocks. It would appear that the deposit of coal was formed before the ore, for in places the coal acts as a wall-rock to the quartz and argentiferous galena of the vein. Nowhere in the district has any such material been discovered except on this property.

On exposure to the weather the coal slacks to a fine powder, but if heated to dull redness and cooled it remains solid. From the composition it burns but slowly, requiring a strong draft and leaving a small residue of white flocculent ashes. No use has yet been made of this coal, but as there are not less than 10,000 tons in sight in the mine it is proposed to employ it in the future as a fuel for steaming purposes. The development of so large an amount of carbon in the workings has made the ventilation of the mine unusually difficult, carbonic acid being given off from the coal; and during periods of low barometer at times so much carbonic acid escapes as to stop all work in the lower part of the mine.

NOTES ON THE DRY LAKES OF SOUTHERN NEVADA AND CALIFORNIA, WITH RELATION TO THE LOESS.

BY WALTER P. JENNEY, E.M. PH.D.

FEATURES of the desert valleys of Lincoln County, Nevada, and of Southern California are the numerous dry lakes and the singular deposits of sediment now forming in their beds. In size these lakes vary from a few acres to more than one thousand acres in extent, the more notable examples being those twenty-five miles southwest of Pioche, the lake twelve miles southwest of Tempahute Peak, in Nevada; the lake six to ten miles northeast of Ivanpah, and that forming the north end of the sink of the Mojave River, in California. It is only in these deserts, in an exceedingly dry country, where rain falls in small amount at best, and at long intervals, where no running streams carry away the material denuded from the highlands, where the valleys are land-locked by ranges of mountains and the lakes which at former periods filled the basins are desiccated until no permanent water remains, that dry lakes are found. To the traveller a dry lake appears, covering the lowest depression of a desert valley as a level flat of smooth, sun-dried mud, buff-brown in color, and elastic, when dry, under the wheels of his carriage, which noiselessly run over the leather-like surface. Most of the lake-surface is bare of all vegetation; along the margin, however, grow scattered bunches of sage brush, and the plants usually associated with it; after heavy rains the lake is covered with a few inches of water; the surface of the mud retains its firmness; it is only when water has stood for some time that the mud softens so that it will not support light vehicles, the water in most cases evaporating in a few days or weeks at the longest, and for the greater part of the year the lakes are dry. Everywhere they are characterized by a level surface; tested by a hand-level, the slopes were in no place greater than five feet to the mile, while the surface of the valleys rise from the shore of the lakes to the mountains, in ever-increasing slopes, from fifty to several hundred feet to the mile. The valleys are covered with loose rock—boulders and gravel washed from the neighboring mountains, the material being

finer and the boulders of less size as the distance from the mountains increases and the slopes become more nearly level; but on the surface of the dry lakes no boulders nor coarse material anywhere appear; a uniform buff-colored sediment spreads over the whole surface of the lake and extends to an unknown depth. This sediment is so compact and homogeneous in texture that when dry it is almost impervious to water; even after a lapse of days water standing on the surface of a lake will be found to have penetrated but a few inches; no pebbles nor any foreign substances are found in it save roots of the sage brush along the margin or occasional small branches of shrubs brought by the water; no form of life exists to furnish fossils; the animals and birds of the desert visiting the lakes for water are so few in number that animal remains must be very seldom preserved; ripple marks and raindrop impressions, if they occur, are obliterated by the evaporation of the water and the desiccation of the mud; the depth of the sediment has not been ascertained, but is probably, in places, many hundred feet; in one instance a well sunk for water penetrated the deposit for a depth of seventy-five feet without going through the sediment, finding it throughout dry and massive, to all appearance, as far as the work extended; only the surface, at starting, for a depth of a few inches, showed any traces of moisture.

The sediment forming the floor of these dry lakes appears, in color, texture, and all physical properties, to be the same in all the lakes, though occurring in localities more than one hundred miles apart, and resembles the deposit of the loess of the Mississippi Valley so closely as to suggest that the origin of the loess may have been due, in part, at least, to the operation of similar causes.

The dryness of the climate, the scanty rainfall, the position of these lakes in the lowest part of broad desert valleys, the extent of nearly level ground with which they are surrounded, permitting the boulders, gravel, and sand washed from the mountains by the occasional rains to be so completely deposited that only the finest sediment in suspension in the water reaches the lakes, causes the uniform character of the deposit and to material thus transported by water the larger portion of the deposit is due, augmented by fine dust brought by the wind and caught and retained by the water.

On evaporation of the water in these lakes the sediment is left as a smooth, leathery coating, effectually protecting the deposit

from the action of wind even after the lake has been dry for some months, sealing and retaining the accumulations undisturbed, while the desiccation of the mud completely destroys all traces of stratification or structure. From the nature of the formation, oxidation by atmospheric influences has been carried to the limit, and the sediment, without regard to the geological formation or rocks of the mountains from which it has been derived, is reduced to a uniform texture and appearance.

Such are the causes now in operation in Southern California and Nevada. How far they are applicable to a correct understanding of the origin and manner of formation of the deposits of the loess, I leave to those who have made a special study of that formation.

CHRONOLOGY OF THE HUMAN PERIOD.

BY J. WOODBRIDGE DAVIS.

THE earliest exact date we have is that of the victory of Coræbus, the runner, at the Olympian festival, July 21st, B.C. 776. Beyond this, uncertainty grows from years into decades and from decades into centuries until, in the earliest existing traditions, it becomes supreme; and yet man's history is not half told.

Of the vast preceding ages from which no word has come, the chronology is necessarily based upon traces of the events themselves. So the best results we can expect from an exploration of this dark region of time are a meagre knowledge of events, a fairly accurate knowledge of successions and a very inaccurate knowledge of durations.

There is, however, an artificial difficulty in the way of the student of archæology; namely, the several scales used in the division of pre-historic time. A like difficulty pertaining to the era of written records has been overcome by means of formulæ for the translation of dates from one scale to another. But no systematic attempt seems to have been made to correlate the various scales applied to the measurement of the older Quaternary.

For instance, the antiquity of a certain "find" is rated by reference to the geological event then taking place; of another, according to a scale indicated by the successive disappearances of wild

HUMAN CHRONOLOGY. (With Reference to Europe).

Geological Data.					Civilization Data.				
	Periods.		Events.	Extinct or Emigrated Mammalia. (Latest Abundant Occurrence.)	Depots. (Earliest Examples.)	Implements.	Interments.	Husbandry, etc.	Architecture.
Quaternary.	Recent.	Historic, About 1000 B.C.	Alluvium,		Books, Inscriptions, Traditions.	Steel (hardened iron). Iron.	Cumbent.	Agriculture, Cattle, Horses, Utensils, etc.	Refined Architecture from Asia and Africa.
		Pre-historic.	Denudations, Lake Deposits, Deltas, Glacial Moraines, Peat-bogs, Raised Beaches, Sunken Beaches.	Aurochs. Urus.	Existing Tumuli, Lake Deposits, Deltas, Ancient Beaches, Moraines, Peat-bogs.	Bronze (hardened copper). (No trace of Copper Age in Europe.)	By Cremation.		Circular Wooden Huts. Pile Dwellings, Picts Houses, Pits, Wheems, Cromlechs, Circles, Cairns, Tumuli.
						Polished Stone or Neolithic.	In Sitting Posture.		
					Coast Finds, Shell Mounds.	Unpolished Stone.		No Agriculture, Dog Domesticated, First Traces of Pottery.	
	Post-Pleiocene.	Late Pleistocene (Terraces).	Land Elevation, Cold Climate.	Reindeer, Irish Elk.	Caves and River Drifts.	Rudely-shaped Stone.		No Agriculture and No Domestic Animals.	Caves.
		Mid Pleistocene (Champlain).	Land Depression, Warm Climate.	Hippopotamus, Woolly-haired Rhinoceros, Mammoth. Cave Lion, Hyena, Cave Bear.		A few simple Flint Flakes.			
		Early Pleistocene (Glacial).	Land Elevation.		Traces of man's existence uncertain.				

Paleolithic

animals from a particular district. Other scales are based upon the progress in human arts and customs, the successive domestication of animals, etc. Each author relies especially upon one or two of these modes of reckoning with occasional references to some of the others. Except to experts, this is confusing.

On this account the chart appended was prepared for private use. Here it is attempted to exhibit the principal scales in their chronological inter-relations. This was accomplished by collecting and arranging all the cross-references occurring in many of the best works, chiefly those of Worsaae, Morlot, Gastaldi, Lartet and Christie, Lubbock, Lyell and Dawkins.

The chart explains itself. All the items occurring together in one column between two horizontal lines, represent the characteristics of the period embraced by those lines. It has been found useful for determining the relation in time of events originally referred to different scales, and it also serves to divide the human period into smaller parts than can any single scale.

The chart relates to Europe only, the most thoroughly investigated of the continents. Even so, its divisions are not contemporaneous for all that land. The dawn of written history in Britain breaks eight or nine centuries after that of Greece. The polished stone and the bronze ages must have rolled over Europe in slowly moving waves. The advancement of the other arts and the domestication of animals similarly spread from men to men, retarded by mountain chains and salty channels. But if these scales were applied to America, the later stone age alone must be shifted at least five thousand years.

NOTES ON BLOWPIPE ANALYSIS.

BY A. J. MOSES.

THE USE OF PLASTER TABLETS INSTEAD OF CHARCOAL.

IN a paper upon "The Application of Hydriodic Acid as a Blowpipe Reagent,"* Dr. Haanel describes tablets of plaster of Paris used by him as a support for the condensation of the volatile iodides. He says: "The tablets are cheap, easily made,

* *Trans. Royal Soc. Canada*, Sec. iii., 1883. Read May 25th, 1883.

cleanly and occupy little space for storage. They are much to be preferred on these grounds to charcoal, even for examinations of oxide coatings, which in some cases come out much more finely upon the tablets than upon charcoal."

The experience of the last two years in the mineralogical laboratory of the School of Mines with large classes of students, has shown that it is best to supplement the charcoal tests by the corresponding tests upon plaster. The coatings differ in position, and to some extent in color. Ignoring the factors of cheapness, cleanliness and color, the essential differences between the two supports are:

1st. Plaster is the better conductor, condenses the oxides closer to the assay, and therefore, the more volatile coatings are thicker and more noticeable on plaster, while the less volatile coatings are more noticeable when spread out on charcoal.

2d. Charcoal supplements the reducing action of the flame, and therefore is the better support where strong reduction is desired.

White sublimates may be studied on plaster which has been blackened by holding in a smoky flame.

A convenient series of tests which utilizes both plaster and charcoal would be:

I. Heat with gentle O. F. upon *smoked* plaster tablet.

Sb.—White pulverulent coat that dissolved in S. Ph. and reduced on coal with tin gives a black bead.

As.—White crystalline coat yielding garlic odor in R. F.

II. Heat with gentle R. F. on *unsmoked* plaster tablet.

Cd.—Dark brown coat shading to greenish-yellow and again to dark-brown.

Zn.—White non-volatile coat, bright green with cobalt solution.

Te.—Deep brown coat that moistened with concentrated H_2SO_4 and gently heated becomes fine red.

Se.—Brick-red to crimson coat, horseradish odor, and, at times, a blue flame.

Mo.—Crystalline yellow and white coat with an outer circle of ultramarine blue.

III. Make a paste with the substance, soda, water and charcoal dust, and heat strongly upon charcoal with R. F.

As.—Garlic odor and a faint, white volatile coat.

Cd.—Brown coat surrounded by a peacock tarnish.

Sn.—White non-volatile coat close to assay, blue-green with cobalt solution.

Zn.—White not easily volatile coat, bright green with cobalt solution.

If any coat forms, examine it for Zn and Sn by moistening it with cobalt solution and blowing a strong blue flame on the substance.

IV. Dig up the coal containing the soda and place it upon a silver coin, moisten with water, crush, heat, and again moisten.

S, Se or **Te.**—The coin will be blackened.

If the soda effervesces during fusion, look for SiO_2 or TiO_2. Examine it also for metallic particles and note whether they are, *e.g.*, malleable, magnetic, brittle, red, etc.

White coats may form from Pb, Bi or alkalis, yellow coats from Pb or Bi, brown or red coats from Cu or Mo, and the ash of the coal may be white or red.

PREPARATION OF THE TABLETS.—A paste of plaster of Paris and water, just thick enough not to run, is spread out upon a sheet of oiled glass* and smoothed to uniform thickness (⅛″ to ¼″) by another smaller sheet of glass, which may be conveniently handled by gumming a large cork to one side, and using it as a plasterer's trowel. While still soft it is cut *through* with a knife into uniform slabs 4″ x 1½″. It is then placed, still upon the glass, in an air bath and dried, after which the tablets are easily detached. In using, a small cavity is made at one end, as with charcoal.

THE IODINE TESTS.

The first use of iodine in blowpiping was made by Bunsen in 1866. Films of oxides were obtained by holding the assay upon a thread of asbestus in the upper O. F. of a Bunsen burner and condensing the fumes upon the lower surface of a glazed porcelain dish which was held in the flame just over the assay, and kept cool by water.

The oxides were then changed to iodides either by volatilizing iodine on asbestus, and condensing it on the film, or by exposure to the vapor of hydriodic acid formed by the deliquesence of phosphorous tri-iodide.

A later method, published by v. Kobell† in 1871, consisted in heating the assay upon charcoal in the R. F. with a flux composed of equal parts of potassic iodide and sulphur ground together.

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* A single drop of oil is enough for a plate 18″ x 18″.

† *Journ. f. pr Chemie*, 1871, vol. iii., p. 469.

Treated in this way, bismuth compounds yielded a bright red band of iodide of bismuth, with sometimes an inner fringe of yellow iodide of bismuth; lead compounds, a strong canary-yellow coating of iodide of lead, at some distance from the assay; and antimony, arsenic, and mercury, faint yellow or reddish coatings far out on the coal. With compounds containing both lead and bismuth, the bismuth red band was slightly nearer the assay than the outer edge of the lead coating, and thus had the yellow of lead on each side.

V. Kobell's method is practically limited in range to separation of lead and bismuth, and furnishes no sure test for a little lead with much bismuth, for the reason that it is impossible to distinguish a small coating of yellow lead iodide from the inner fringe of yellow bismuth iodide.

Cornwall found* that for combinations of lead and bismuth in which either element greatly exceeded the other, the best distinction could be made by heating the substance and flux in an open tube. The yellow lead iodide sublimate formed at one half to two-thirds of an inch above the assay, while the bismuth iodide appeared as a dull brick-red band or streak slightly within the outer edge of the lead sublimate.

In 1883 Dr. Haanel described† a method of obtaining tests with hydriodic acid upon tablets of plaster of Paris by which seventeen elements yielded volatile sublimates more or less characteristic in position, color or order of formation. In certain cases two or more elements could be determined by a single test, either by noting the resultant color when coats formed together and were superposed, or by noting the position when the volatility differed, or, when the affinity for iodine differed, by noting the successive coatings as they formed. In using the tablets, which are described in the preceding note, the substance to be tested is placed in a cavity at one end, moistened with the acid and heated gently in the O. F. Similar coats were differentiated by exposure to vapor of ammonia,‡ or by moistening with ammonic sulphide.

Haanel's tests are unequalled in beauty and distinctness; the

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* *Am. Chemist*, March, 1872.

† *Trans. Roy. Soc. Canada*, sec. iii., 1883. Read May 25th, 1883.

‡ I find that the ammonia evolved by heating a crystal salt of phosphorus just below the sublimate is sufficient to produce the more important changes. In field work this would be an advantage.

hydriodic acid is absorbed by the plaster, and yielded gradually. The acid, however, is expensive, unstable, and inconvenient for field work; but for laboratory work will be found most satisfactory.

Messrs. Wheeler and Luedeking* found that either tincture of iodine or the dry iodine scales would yield sublimates *with sulphides*, and that a flux made by adding two parts of iodine to three parts of melted sulphur, cooling and pulverizing, if used slightly in excess with the powdered substance, would give results practically equivalent to those obtained by Haanel.

This sulpho-iodide flux yields its iodine very rapidly and not gradually as with the acid; but if used in excess the tests differ from those obtained with the hydriodic acid only in the frequent presence of sulphur and sulphide sublimates. Being a solid, this flux is more satisfactory for field work than the acid.

Mr. P. Casamajor, in 1885, stated† that a large number of elements, including iron, chromium, and manganese, would yield sublimates in glass tubes if mixed with a paste of silver iodide and a little charcoal dust. The advantages claimed were speed, distinctness, absence of sulphides, and dryness of reagent. The tests resemble those obtained on plaster with the other fluxes; but the speed and distinctness do not compare favorably with the tests on plaster.

In experimenting with the different fluxes, I found that if the v. Kobell flux was used in conjunction with the rapidly chilling plaster support of Haanel, and especially if the flux was "*accelerated*" by the addition of potassic bisulphate, the coatings approximated very closely the Haanel tests in variety and distinctness; and it could be claimed that with two important elements, mercury and bismuth, the tests were made more peculiar and characteristic.

With a flux composed of two parts sulphur, one part potassic iodide, and one part bisulphate of potash, the coatings from copper, zinc, lead, arsenic, antimony, selenium and tellurium were substantially the same as those obtained with hydriodic acid. Cadmium gave the white iodide upon smoked plaster. The differences were:

Cadmium.—Brown to yellow oxide near assay, purplish-brown at distance, becoming brown when touched by the O. F.

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* *Trans. of St. Louis Acad. of Science*, vol. iv., No. 4, 1886.

† Chem. News, Vol. 52, p. 1.

Mercury.—Crimson and yellow if gently heated, black and yellow if strongly heated.

Bismuth.—A slight inner yellow, then a beautiful scarlet, shading into a combination of chocolate-brown and scarlet, but all made red by ammonia.

For a large laboratory or for field work, such a flux possesses certain advantages over both the liquid preparation and the fusion mixture. It yields all the important tests with a very small overproduction of iodine fumes and it is cheaper, more stable, and more easily prepared. The proportions recommended are about equal weights of potassic iodide and potassic bisulphate, with one or two parts of sulphur. The components to be ground separately and then mixed.

The important iodine tests may then be satisfactorily produced upon plaster with the Haanel, the Wheeler-Luedeking, or the "accelerated" v. Kobell flux.

In spite of the great range of the iodine tests, in practical work upon unknown *compounds* the elements which can safely be determined by them are only four or five in number, other results, if obtained, being most safely considered only as indications or confirmations.

The following may be given as a convenient arrangement or scheme:

Mix the substance with more than an equal amount of the flux, and heat gently in the O. F. upon a plaster tablet.

Copper.—White.* Colors R. F. green.

Cadmium.—White. Made yellow by ammonic sulphide.

Zinc.—White. Disappears at once with ammonia.

Lead.—Chrome-yellow; copious, darker hot. Upon coal is copious yellow or greenish.

Tin.—Brownish-orange. This test can be most satisfactorily made with the hydriodic acid.

Arsenic.—Reddish-orange shading into yellow, very dark hot. Made lemon-yellow by ammonic sulphide.

Antimony.—Orange-red to peach-red. Made orange by ammonic sulphide.

Mercury.—Scarlet near assay, yellow at a distance; becomes all scarlet, very volatile. With the v. Kobell flux, if too quickly heated, the sublimate will be clouded with black.

* White coatings are obtained upon plaster which has been blackened by smoke.

Selenium.—Reddish-brown, almost scarlet.

Bismuth.—With the acid or sulpho-iodide. Dark velvety chocolate-brown, sometimes fringed with red near assay and usually showing red and yellow at distance; but with the v. Kobell flux, bright scarlet surrounded by chocolate-brown with, at times, a reddish fringe. Becomes orange-yellow, then cherry-red, with ammonia. Upon coal a bright red band with sometimes an inner fringe of yellow.

Tellurium.—Purplish-brown with deep brown border. Disappears with ammonia.

Molybdenum.—Deep ultramarine blue.

In addition to the preceding tests, the following are recorded:

Upon Plaster with Hydriodic Acid. (Haanel).

Silver.—Grayish-yellow close to assay, brighter hot.

Thallium.—Orange-yellow near assay, purplish-black and salmon farther away; becomes ultimately yellow.

Gold.—Pink to purple near assay, faint yellow at a distance.

Cobalt.—Greenish-brown, passing into green. Brown disappears if breathed upon.

Tungsten.—Faint greenish-blue.

In Glass Tube with Silver Iodide. (Casamajor).

Iron.—Yellow, streaked with brown; the yellow whitens on cooling.

Chromium.—White near assay, but darkens by further heating.

Manganese.—Yellow, hot; white, cold.

A BRIEF REVIEW OF THE LITERATURE ON ORE-DEPOSITS.

BY J. F. KEMP.

(Continued from page 123.)

In 1841 William E. Logan, afterwards knighted, came to Canada from Swansea, in Wales, where he had been for nine years engaged in mining and smelting. In 1841 the Canadian Survey was begun, and in 1842 Logan became its director. It continued under his charge until 1869, in which year he resigned. A. R. C. Selwyn then became director, and under Mr. Selwyn the survey has been active to date, and is still in operation. Annual reports of progress are published, and these contain, scattered through them,

many valuable descriptions of the ore-deposits of the Dominion. Dr. T. Sterry Hunt was early connected with the survey as chemist and mineralogist, and chiefly from his pen have come the descriptions published previous to the seventies. Since then, however, this work has been especially done by Dr. B. J. Harrington, Mr. H. G. Vennor, and Eugene Coste, M.E. Dr. Hunt had also much to do with the metamorphic and oldest crystalline rocks, and came thus to write concerning the chemistry of the first beginnings of the globe; and, in connection with such speculations, has published somewhat on ore-deposits. In 1863 all the annual reports previously published were summarized in one large volume, of which chapter xxi. treats of economic geology. The descriptions of the copper-deposits are especially full.

In the years immediately following great interest was excited in the gold-deposits of the eastern provinces, and the several papers cited below appeared.* As elsewhere, the gold was found in quartz veins in metamorphic rocks. In the report, 1866–70, Hunt has a paper on iron-ores, which is chiefly of interest in this connection, because it treats of the magnetite sands of the St Lawrence. Later, in the report for 1873–74, pp. 192–259, Dr. B. J. Harrington reviews the iron-ores more completely, and suggests much of interest regarding their probable origin. He advocates for the magnetites a probable original limonite, but he outlines as well the beach sand theory, which was later (1882) independently brought out by A. A. Julien (see above, p. 121). Dr. Harrington pronounces some of the magnetite bodies to be undoubted veins. Mr. H. G. Vennor discusses certain of them further in the reports for 1874–75, pp. 112–122; 1876–77, p. 296; and traces three distinct horizons of deposits, each with a more or less characteristic percentage of TiO_2. Mr. R. W. Ells, in the report for 1874–75, describes certain red hæmatite deposits in the Cambro-Silurian slates of Carleton County, N. B., somewhat similar as regards associations to the limonite mines along the New York and New Eng-

* Marsh, O. C., "Gold of Nova Scotia," *Am. Jour. Sci.*, vol. xxxii., Nov., 1861. Hunt, T. S., "Canadian Gold," *Canadian Naturalist*, Feb., 1863. Logan, W. E., "Notes on the Gold of Eastern Canada," *Geol. Surv.*, 1864. Michel, A., and Hunt, T. S., "Report on the Gold Regions of Canada," *id.*, 1866. Hunt, T. S., "Report on the Gold Regions of Nova Scotia," *id.*, 1868. Selwyn, A. R. C., "Report on the Gold Fields of Quebec and Nova Scotia," *id.*, 1870–71. This last paper is especially full of interest.

land border. In the report for 1882–83–84 (*k*), Eugene Coste describes the gold quartz veins of the Lake of the Woods region, and in the report for 1885 the same writer gives a digest of Canadian mining law; and in the report for 1886 a series of mineral statistics. Scattered all through this long and valuable series are notes on the ore-deposits of the northwest territory and other outlying portions of the Dominion.

In 1875, Dr. T. Sterry Hunt brought out a volume entitled *Chemical and Geological Essays.* It consisted of various papers which had been previously published, but were now for the first time collected in one volume. They treat especially of geological chemistry, the circulation of the various natural solutions, the deposition of minerals, and especially those misty questions of metamorphism, the origin of the earth, and the chemistry of the early globe. The author possesses a remarkable familiarity with the literature, and had previously had very considerable opportunities for geological experience in connection with the Canadian Survey. He evinces an exceptional ability to range in order views and facts from other sources to establish his own thesis; but however familiar we may become with his own views, we cannot but be impressed with the fact that the papers are illustrations of special pleading, and we may sometimes doubt whether the everlasting truth of the various matters is brought out any the clearer by them.

The *First Annual Report of the Missouri Survey* appeared in 1853, and is a small volume; but the second, in 1854, is of goodly size, and contains descriptions of the iron- and lead-deposits by Dr. A. Litton, and much of great historical value. We have at this point especially to do with iron. Developments were not very extended at the time; but so far as they admitted, the ore-bodies at Iron Mountain, Pilot Knob, and Shepherd Mountain were studied, and barring some extravagant estimates of the amount of ore available, were faithfully described.

In 1872, Raphael Pumpelly became director of the survey, and in 1873 published a large and valuable volume on the *Iron-Ores and Coal-Fields.* The geology of Iron Mountain and Pilot Knob is carefully described by Pumpelly (pp. 1–28), and subsequently the ore-deposits are taken up by Dr. Adolf Schmidt, and quite extensively treated. Dr. Schmidt considers them, whether occurring in an undoubted bed, as at Pilot Knob, or in various more or

less irregular veins, as at Iron Mountain, to have been formed either by a replacement of the porphyries with iron oxide deposited from solution, or by a filling in the same way of fissures probably formed by the contraction of the porphyry in cooling (pp. 98, 109, 116). J. D. Whitney had previously ascribed to these ores, consistently with the Michigan hæmatites, an eruptive origin (*Metallic Wealth, U. S.*, p. 479, 1854), and at about the same time with the appearance of Schmidt's paper, J. R. Gage, an assistant on the survey, discusses them (*Trans. St. Louis Acad. Sci.*, vol. iii., No. 1, 1873, pp. 181–192), and also reaches the conclusion that the Pilot Knob bed originated by replacement, and that the iron was derived by lateral secretion. The replacement form of origin for Pilot Knob has the indorsement of Pumpelly, and it is interesting to note that Irving ascribes to him the suggestion of its application in Wisconsin.* The origin of these Missouri deposits must be esteemed by any one who has seen them an obscure point, but to most minds the explanation advanced by Schmidt would certainly appeal with most force. In reference to the general geology of the Archæan outcrops, it may be added that in the volume of the survey published in 1874, p. 342, G. C. Broadhead takes up the geology of Madison County to the east of the hæmatite outcrops, and adds much to our knowledge; and Dr. Erasmus Haworth, in an inaugural dissertation published in the *Amer. Geologist* (May and June, 1888), discusses the granites, porphyries, and dikes from microscopic sections.

Schmidt, in the report above cited, next takes up the deposits of red and specular ores which occur in the second sandstone of the Missouri Survey (Lower Silurian) throughout the central part of the State, and after these certain deposits of red hæmatite in the Carboniferous. To all an origin by replacement of pre-existing rock, or by deposit in hollows of the then-existing surface is ascribed. In the report for 1874, P. N. Moore describes the limonite ores of southeast Missouri, attributing to them from their uniform stalactitic character an origin by simple deposition from solution.

In the annual report for 1854, Dr. Litton also describes the lead mines which were then operated in the southeastern part of the

* *Amer. Jour.*, iii. ser., vol. xxxii., p. 260. Compare also THE QUARTERLY, this volume, p. 121.

State. Four productive counties, Franklin, Jefferson, St François, and Washington receive very careful treatment. We learn that the galena was uniformly obtained either from the overlying clay beds or from pockets, caves, and irregular cavities in the rock immediately underlying the decomposed surface material. These cavities, as remarked by J. D. Whitney (*Met. Wealth*, p. 419), seem to resemble in all respects the gash veins of the regions further north. The miners avoided the solid rock, and for this reason the larger so-called "disseminated" deposits now extensively worked escaped attention. In the report published in 1874, J. R. Gage also described the lead region of the southeastern part of the State, and brings out clearly the "disseminated ores." These ores occupy no pre-existing cavity, and seem to have been formed at the same time with the enclosing dolomite. If we attribute to the gash veins the method of filling advocated by Whitney and Chamberlain (see above, p. 117), that is, by the leaching out of galena which had been precipitated at the same time with the dolomite, these disseminated deposits may represent such unleached galena. This explanation was advocated by the reviewer in a brief note in THE QUARTERLY, vol. ix., p. 74.

Likewise in the report for 1874 (p. 384), Dr. Schmidt and Alexander Leonhard have taken up the lead and zinc deposits in the subcarboniferous strata of the southwestern part of the State, and have applied in a very able way the well-known theory of "dolomitization" to their explanation. On his return to Germany, Schmidt republished, in 1876,* his views, with somewhat greater amplification. He traces six periods in the history of the deposits. 1. Period of rock-formation. 2. Period of consolidation, with formation of joints. 3. Period of dolomitization from the joints outward, of shrinkage, and of ore deposition as sulphides. 4. Period of solution and removal of calcite from certain strata and continued deposition of ores. 5. Introduction of silica as quartz, and alteration of blende to calamine. 6. Period of oxidation of sulphide ores. Dr. Haworth,† in 1884, described the Kansas extension of

* *Die Blei-und Zink Erzlagerstätten von Südwest Missouri*, Heidelberg, 1876. It may not be out of place to mention at this point that Dr. Schmidt published in 1881 a very interesting monograph on the "Zinkerz-Lagerstätten von Wiesloch in Baden," ore-bodies quite different from Missouri, but a paper which is the continuation of the author's studies begun as above.

† *A Contribution to the Geology of the Lead and Zinc Mining District of Cherokee County, Kansas*, Oskaloosa, Ia., 1884.

these ore-bodies. In the same (1874) report the lead-deposits of the central part of the State are taken up, but they are much less important than either those of the southeast or southwest, and seem to afford phenomena not greatly differing from those already mentioned, except perhaps the so-called circles (cf. p. 501, and ff.), which are like a conical stockwork. Missouri possesses a wonderful richness in mineral deposits, and has made some of the most important and interesting contributions to be found in the literature.

In 1866 Congress authorized the appointment of a Commissioner of Mining Statistics to gather facts respecting mining in the States and Territories west of the Rocky Mountains. Secretary McCulloch selected J. Ross Browne as the first commissioner and as the result of his work two volumes (1867 and 1868) were published. He was succeeded in 1869 by R. W. Raymond, under whom eight volumes were brought out. These volumes contain chiefly a catalogue of western mines arranged by States and counties, with a mining commentary, descriptive of the development and prospects of each. At the close of the volumes, however, a series of papers was generally appended, bearing on metallurgical and mining subjects, which are of great value. In the Report for 1870, p. 447, Dr. Raymond has written a very excellent paper on "Mineral Deposits," which is a general review of the forms of deposit, their origin and principles of classification. The general scheme adopted is that of Professor Lottner, of the Berlin School of Mines.

A. Superficial Deposits, I. Deposits of debris.
II. Surface formations in place.

B. Enclosed Deposits. I. Sheet or tabular deposits.
a. Lode. *b.* Beds and seams.
II. Mass deposits.
a. Masses. *b.* Impregnations, etc.
III. Other irregular deposits.
a. Pockets distributed in other deposits. *b.* Isolated segregations, gash veins, etc.

The American Institute of Mining Engineers was organized at Wilkesbarre, May 16th, 1871. In 1873, the first volume of its invaluable series of *Proceedings* was published, and these have become the repository of some of the best papers upon subjects

related to mining. While no special mention of papers is made at this point, frequent reference will be made to them in foot-notes.

The annual Report of the Austrian Geological Survey for 1873,* contains a monograph by F. Posepny, one of the most eminent of the European mining geologists on the lead and zinc ore-bodies at Raibl in the Austrian province of Kärnthen. Deposits of galena and blende are found in Triassic limestone, clearly filling caves, while in a dolomite lying above the limestone are deposits of calamine which have as clearly originated by replacement of the dolomite by the so-called "metasomatic" process, *i.e.*, molecule by molecule. This process will be further enlarged upon in speaking of the Leadville monograph, for Posepny's paper has been very suggestive to other investigators and is most excellent. The following year, the same geologist published through the Hungarian Geological Society† a monograph on the ore-bodies at Rezbanya in southeastern Hungary. These are deposits in mesozoic limestone, associated with eruptive rocks and contain the greatest abundance of minerals, but are chiefly mined for gold. The ores seem to fill cavities in the limestone in connection with faults.

The Second Geological Survey of Pennsylvania was inaugurated in 1874 with J. P. Lesley in charge. The circumstances attending on the first survey and the publication of its results in Edinburgh, in 1858, by H. D. Rogers, are very generally familiar. The reports of the second survey contain the material which is of chief interest in this connection. Reports D (1875) and DD (1878), by Frederick Prime, describe the limonite deposits of the Lehigh district. The ore occurs associated with beds of so-called hydromica slate interbedded with dolomites of Cambrian and Lower Silurian age. There are two such beds (DD, p. 23), one just over the Potsdam, one between the dolomites and the Hudson River slates. Prime‡ advances the hypothesis that the ore has primarily reached its position associated with the slates, because they being impervious retained the ferruginous solutions; and that the iron was derived either by being dissolved out of the dolomite as carbonate and silicate, or by the alteration of pyrites; and that the potash, abundantly present in the slates, probably assisted in precipitating

* *Yahrbuch der k. k. geolog. Reichsanstalt*, Bd. 23, 1873.

† *Geologisch-montanistische Studie der Erzlagerstätten von Kesbanya.* Buda-Pesth, 1874.

‡ See also *Proceedings Inst. Mining Eng.*, III., 410.

it from solution. In Report C (1876), pp. 136 ff., Persifor Frazer takes up the similar limonite deposits in York and Adams counties to the south, but advances a somewhat different form of origin. Frazer* finds the hydromica slates filled with casts of pyrites crystals and argues thence, that the iron oxide was derived from such pyrites. The chemistry of the changes is the following, the pyrites, FeS_2, altered to ferrous sulphate and free sulphuric acid. The latter reacted on the alkali of the slates, affording sodium sulphate. This meeting calcium carbonate afforded calcium sulphate and sodium carbonate. The latter then precipitated the iron from the sulphate as carbonate and this quickly oxidized to hydroxide. Both these views are modifications of the idea originally advanced by Dr. Jackson,† of the first survey, that these deposits originated *in situ*. Another hypothesis had been early expressed and advocated by many, which was that these limonite deposits were derived by drainage from the old Allegheny Highlands and then precipitated where they are now found. Others, that they were precipitated around the edges of a ferruginous sea, and were even of Tertiary age.‡

In Report CC (1877), Frazer§ takes up the Dillsburg group of mines and shows them to be deposits of micaceous hæmatite and magnetite in Triassic sandstones. In Report F (1878), John H. Dewees treats of the fossil ores of the Juniata district. These comprise limonites and red hæmatites of Marcellus, Oriskany and Clinton age. In Report QQ (1876), I. C. White describes the limonite deposits (the so-called "buhrstone" ore), which fill cavities in Carboniferous limestone in Laurence County (Western Penna.), and they are thought by him and by J. P. Lesley (pp. xv., xviii.) to be probably cave fillings, or in some cases replacement deposits. In Report L (1876), p. 98, Franklin Platt describes the spathic ore-deposits of Fayette County (Southwestern Penna.), and in H 5 (1880), W. G. Platt has many references to the similar ores of Armstrong County (Western Central Penna.).

It has been a time-honored custom for the students in the École

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* *Idem*, p. 421.

† Jackson *Ann. Rep. First Penna. Survey*, 1839.

‡ Rogers, H. B., *Trans. Ass. Am. G. and N*, 1842, p. 345. Hitchcock, E., *Geol. Vt.*, vol. i. p. 233. Lesley, *Iron-Manufacturers' Guide*, p 501, and Rept. A. *Second Penna. Survey*, p. 83. Newberry, J. S., *International Review*, Nov. and Dec., 1874.

§ See also *Inst. of Min. Eng.*, v. 132, and by T. Sterry Hunt, iv. 319.

des Mines in Paris to make excursions into mining districts abroad. Professor L. Moissenet had while yet a student visited Cornwall. In later years he continued his studies thus begun. His papers, originally published in French, were, in 1877, abridged and translated by J. H. Collins and published in London.* They make an interesting little book, and endeavor to explain the local enrichments of the veins. We also find in an appendix a presentation under mathematical guise of the curious imaginative flights of Élie de Beaumont and the application of his so-called pentagonal networks to explain the Cornish veins.

In 1879, Albrecht von Groddeck (1837–1887), director of the Mining Academy at Clausthal, published his *Lehre von den Lagerstätten der Erze*, a book that is the best and most scientific treatise on ore-deposits yet published. After a few introductory remarks the author states his principal grouping as follows:

1. Stratified deposits.
2. Massive deposits.
3. Cavity fillings.
4. Metamorphic deposits.

This, it will be noted, follows as far as is possible the principles observed in rock classification and is commendable for the reason that it brings out the genetic analogies with rocks. The stratified group is subsequently subdivided as *a*. Surface deposits, and *b*. Interstratified.

The second division is analogous to our massive or eruptive rocks, and refers to the original separations of iron oxide, chromite, etc., in certain massive rocks in quantities sufficient to be of value.

The cavity fillings are subdivided into two classes as regards origin, the one depending on the formation of a crack by drying, shrinking, cooling, bending, pressure, etc., the other by solution and removal. Hence, we have: *a*. Fissures (fissure veins, bedded veins). *b*. Caves. Lastly, the metamorphic group formed by the alteration of a rock into ore generally affording a deposit of quite irregular form.

The author then takes up in order these different classes and enlarges upon them. Under veins, for instance, contact veins, reticulated veins, parallel veins, etc., are mentioned as structural

* Observations on the Rich Parts of the Lodes of Cornwall. London, 1877.

varieties, while the varieties of cave-fillings, massive and metamorphic deposits are grouped together as in v. Cotta and Grimm under irregular deposits (Stöcke, Butzen, Nester, terms difficult to render into English). The ore-deposits of the world are then taken up and treated under the following grouping:

*A. Primary deposits.

(Formed at the same time as the walls.) { I. Stratified. II. Massive.

(Formed later than the walls.) { III. Cavity fillings. *a.* Fissure veins. *b.* Cave-fillings. IV. Metamorphic deposits.

B. Secondary or detrital deposits.

The author has endeavored to classify the ore-deposits of the world under fifty-seven different types. Some well-known locality is selected to give name to the type, as, for instance, "Typus, Iron Mountain, Characteristic, enclosures of specular hæmatite in massive rocks," and then under this all the other known similar occurrences are briefly outlined. This is thoroughly scientific so far as it is possible to apply such principles to the grouping of so diverse phenomena, and it also enables us to compare at once any new deposit with the other known related ones. An admirable review of the various theories of formation and suggestions for their future investigation concludes the book.

In 1880 Posepny, of whom mention has been made above, published at Vienna a volume entitled *Archiv für Practische Geologie.* The book is planned somewhat on the lines of v. Cotta's *Gangstudien* (see above p. 58), and is intended to be a serial and to contain contributions to our knowledge of ore-deposits. Various Austrian mining districts, especially in the Tyrolese Alps, are discussed, of which the most interesting is near Klausen on the southern watershed. The ore-bodies are contained in a great mass of intrusive diorite and the neighboring slates, mica schist and so-called felsite schist. The deposits are of especial interest because they illustrate in a striking way the change of metallic contents with a change of wall rock. In the diorite and the slates the veins produce lead, silver and zinc, and are richest of all in the diorite. In the felsite schist and mica schist they afford copper. Posepny

* *Cf.* Lead Deposits of Eureka, Nev., Curtis, p. 118.

explains it by supposing the copper veins to have been formed first, and then the lead-silver subsequently, either solely by a change in the character of the solutions or by this coupled with a later formation of fissures in the diorite. He expresses himself as more favorably disposed toward these methods than toward a "mysterious" lateral secretion or precipitating influence of wall rock. The book closes with a general essay on the relations of geology to mining and a short account of the organization and importance of the geological surveys in all the countries possessing them in 1880. We infer from the preface that another volume is in preparation, which may be expected to prove, like its predecessor, an extremely valuable contribution to the literature.

COMMITTEE* APPOINTED TO CONSIDER THE BEST METHOD OF ESTABLISHING INTERNATIONAL STANDARDS FOR THE ANALYSIS OF IRON AND STEEL.

OBJECTS.

IT is proposed that the Committee shall co-operate with other similar committees in the more important iron-producing countries, in order to provide standard specimens of iron and steel, the chemical composition of which shall have been carefully determined. The specimens adopted as standards shall be intrusted to some recognized official authority, such as the Standards Department of the Board of Trade, and shall be used either for reference in the determination of the accuracy of any proposed method of analysis, or for controlling the results of analyses in any cases of importance which may from time to time arise.

SUGGESTIONS.

1. Professor J. W. Langley, of the University of Michigan, U. S. A., to be requested to superintend the production of the

* British Association for the Advancement of Science, Section B. Committee: Prof. Roberts-Austen, F.R.S. (Chairman); Sir F. Abel, C.B., F.R.S.; Prof. Langley; Edward Riley; G. J. Snelus, F.R.S.; John Spiller; Prof. Tilden, F.R.S.; and Thomas Turner (Secretary).

samples; that they be prepared and preserved in accordance with the directions to be furnished by the committee; and that an equal portion of each sample be forwarded to the several secretaries of the respective committees in the United Kingdom, America, France, Germany, and Sweden.

2. The specimens which are eventually to be adopted as standards to be supplied to not more than seven representative chemists of repute in each of the countries above mentioned, who shall be requested to analyze the specimens by any method or methods they may prefer.

3. In the event of the analyses giving results which in the opinion of the committee may be regarded as sufficiently concordant, the means of the analytical results of each of the several constituents to be adopted as representing the composition of the standards; the report on the analytical results not to be issued before the various analysts, to whom the samples have been submitted, shall have had an opportunity of examining it. The standards shall hereafter be distinguished only by letters or numbers.

4. The attention of the committee to be for the present confined to four samples of steel, selected as containing as nearly as possible 1.3, 0.8, 0.4, and 0.15 per cent. of total carbon respectively. In addition to the determination of the amount of carbon present in each condition, the phosphorus, sulphur, silicon, manganese, and chromium also to be determined.

5. 150 kilos. of the samples selected for examination as standards to be prepared in all. This would give, after allowing sufficient for the required analyses, quite 5 kilos. of each standard for each of the five countries interested, allowing say 10 grams for each applicant who may desire to use the standards; this would permit of 500 appeals to each of the four standards in each country, or at least 10,000 appeals in all.

6. The samples to be analyzed in the United Kingdom by W. Jenkins, Dowlais; Edward Riley, London; J. E. Stead, Middlesbrough; The Royal School of Mines; G. S. Packer, of the Steel Company of Scotland; and two others.

7. The metal of which the samples are to be produced to be cast in small ingots, special care being taken to prevent any irregularity of composition. After the removal of the outer skin the metal to be cut by a blunt tool in the form of thin shavings, then crushed, sieved, and intimately mixed.

8. The samples thus prepared to be preserved in separate small quantities (say of 30 grams each), which shall be hermetically sealed in glass tubes so as to prevent oxidation.

9. These preliminary arrangements of the committee to be communicated to the leading technical journals.

THE SCHOOL OF MINES.*

BY PROFESSOR J. H. VAN AMRINGE.

MR. PRESIDENT AND GENTLEMEN,
ALUMNI OF THE SCHOOL OF MINES:

I APPRECIATE the privilege which, by invitation of the governing committee of your association, has been accorded me of addressing you this evening. The committee kindly gave me the largest latitude in the selection of a topic, and it has seemed to me that, as the School of Mines is now just completing twenty-five years of life, no theme could be more appropriate than the school itself. I shall not attempt, however, in the interval between a business meeting and a collation, to treat so large a subject exhaustively, but shall be as brief as possible.

Early in 1863, the project of establishing a school of mines and metallurgy in New York City began to be agitated. The nation was then engaged in a stupendous struggle for existence, and the period referred to was the most gloomy of all the terrible four years from 1861 to 1865. Discouraging as the situation appeared, the people, nevertheless, confidently looked forward to the salvation of the national life, though at the expense of a vast debt. To provide for the payment of this debt, the material resources of the country must needs be developed skilfully and economically, and circumstances were, therefore, opportune for the founding of a school of applied science.

At that time, Columbia College was in somewhat straitened circumstances. It had a large endowment, but much of it was unpro-

* An address delivered at the June meeting of the Association of the Alumni of the School of Mines, and printed by request of the Association.

ductive and a source of expense rather than of income. This should be borne in mind, that you may properly appreciate the hesitancy of the college to assume pecuniary responsibilities other than those which its charter made imperative.

The establishment of the School of Mines was due, primarily, to Professor Egleston. In March, 1863, he drew up a plan, setting forth the object of such a school, outlining a course of instruction, and giving an estimate of its cost. This plan was presented to the trustees of the college at their meeting in April, 1863, and was accompanied by a suggestion "that the legislature had in contemplation a design of making a large grant of lands for the purpose of aiding scientific investigation." The trustees appointed a select committee to report upon "the subject of the expediency of establishing such school and of procuring a grant of land from the legislature." That committee reported, in the following month,

"That the establishment of such school would, in their opinion, promote the interests of this college and of the community at large; but that its complete organization with the necessary apparatus, collections, etc., would require an outlay estimated at between seventeen and eighteen thousand dollars, and is therefore not expedient at the present time.

"The committee are of opinion, however, that the nucleus of such school may be formed at inconsiderable cost to the college, and so as to be capable of expansion whenever the means of the college shall permit. They therefore recommend that rooms be selected and set apart for the use of such school within the present college building, that post-graduate or university professors of analytical chemistry, of mining and metallurgy, and of mineralogy and geology, and instructors in the German and French languages be appointed; such professors and instructors to be compensated wholly by fees; and that the collections and apparatus belonging to the college be used for the purposes of instruction in the school, under such regulations as will prevent any interference with their use in the undergraduate course."

The recommendations were approved, and in the following December, on further report from the committee, the trustees authorized the setting apart of rooms in the college building for a mineralogical and geological cabinet, the appointment of a professor without salary, and the expenditure of $500 for fitting up cases for speci-

mens, etc. On February 1, 1864, Mr. Thomas Egleston was made professor of mineralogy and metallurgy. At the commencement, in the following June, Dr. Barnard, of illustrious memory, became president of the college—a significant fact in the history of the school. In September, Mr. F. L. Vinton, and in October, Mr. C. F. Chandler were appointed professors, respectively, of mining engineering and chemistry. A considerable collection of minerals, in addition to such as the college already possessed, had meanwhile been obtained through the contributions of friends, modest laboratory accommodations had been provided, several professors of the college volunteered their services in their respective departments, and on Tuesday, November 15, 1864, the School of Mines was opened in a basement of the old college building.

It must not be understood that the college had thus committed itself to the financial support of the school. By no means. It was not contemplated, at that time, that the school would become a considerable charge to the college. It was expected that a portion of the grants of land made by Congress for the encouragement of scientific institutions might possibly accrue to the benefit of the school, and that, in any event, friends of scientific education and persons interested in the material development of the country would contribute the funds for its maintenance. The venture was largely a personal one, founded upon hope and faith—hope of ample support and possible endowment from without, which was doomed to disappointment, and faith that excellence of results would induce adoption by the college, which was abundantly justified.

The immediate success of the school was beyond expectation. The special committee reported to the trustees, December 5, 1864,

"That the school was opened on the 15th of November in the rooms provided by the college, and is now in operation with every prospect of success. Twenty-nine students are in attendance at the date of this report, and it is probable their number will be greatly increased if room can be found for their accommodation. The faculty did not hope for more than fifteen during the first year.

"This fact confirms the committee in the opinion it has heretofore expressed that the community feels the want of a school of applied science, and especially of a school intended to promote the development of the mineral resources of the country, and that this institution, if judiciously fostered in its infancy, will speedily attain an importance that will do honor to the college and to the

city. The establishment of the school has attracted the attention and interest of our alumni, of men of science, and of holders of mining property, the value of which its success will increase. It has been noticed in foreign periodicals. It has already obtained for the college contributions of money and of scientific material exceeding in value all donations which the college has received from any source (the Gebhard legacy excepted) for many years past.

"The faculty of the school express themselves surprised and gratified by the intelligence and earnestness of the students. They report the average age of these gentlemen to be about twenty-three, and that most of them have received a college education. They also state, after several years' acquaintance with the scientific schools established by government in England, France, and Germany, that the young men of this country, as represented in our School of Mines, are unsurpassed in capacity for scientific training."

The "contributions of money," so approvingly mentioned, were stated in the report to be $2450 for general purposes and $500 for the purchase of minerals. The contributions, at no time, amounted to any considerable sum. The trustees were frequently obliged to make additional appropriations out of a somewhat scant treasury, and, though they exerted themselves, as in duty bound, in every way—by the appointment, as "associates of the committee of the School of Mines," of gentlemen interested in the development of the mineral wealth of the country, by appeal to the public, by the offer of a contingent endowment of $250,000, etc.—to relieve themselves of at least a part of the financial responsibility, they proved themselves, in every emergency, steadfast friends of the project.

In February, 1865, the committee on the school reported against a proposed new corporation, and continued as follows:

"The committee beg leave to remind the trustees that when it was determined to make the experiment of establishing a School of Mines under the impression that such an institution was needed, it was understood and believed that the school would be able to maintain itself with the aid of the rooms that the college could, without inconvenience, grant for its use, and with such pecuniary contributions as might be procured from those who were interested in its objects or in the general advancement of science, and that no

assistance in money would be required from the college. The trustees, it is believed, felt themselves bound to foster the design to acquire and extend scientific knowledge applied to practical knowledge, so far as they might do so without conflicting with their higher and more specific duties in promoting 'a liberal education,' and instructing 'youth in the liberal arts and sciences' as practiced in their sub-graduate course. They therefore promptly seconded the design, and appointed the necessary professors without salary. These professors accepted the position on this condition, and, as a matter of course, did not look to the college for compensation for their labors, but solely to the school or other sources. With this understanding the trustees, on request of the professors, consented to permit the school to be opened this autumn, being a year in advance of the time originally contemplated. It was thought that the need of such an establishment in this city was urgent, and the necessary preparation was made for the reception of twenty students. The result proved that there was, in fact, a demand for such instruction, for about thirty students at once offered themselves, a number, it is represented, which is now augmented to about forty-three.

"The augmentation of the students rendered additional preparations for their reception and instruction, especially in the laboratory, indispensable, and this led to increased expense; and as the voluntary aid fell far short of what was expected, the very success of the school became a subject of embarrassment. In this condition of things the committee were induced, although with reluctance, to recommend an appropriation of $2250, which was, as they were led to believe, all that would be required to carry the school successfully through the present term. This appropriation the trustees promptly made, in compliance with the recommendation."

And, on like recommendation, the trustees, at the same meeting, made an additional appropriation, and, further, resolved to set apart a building for the use of the school. On the 6th of March following, they enacted a statute organizing the School of Mines, thus making it, in name and in fact, what was apparent it must sooner or later become, a co-ordinate branch of Columbia College. As a graduate of the college, and as one deeply interested in the affairs of the school from its inception to the present time, I am

glad that the honor of establishing it upon its broad and sure foundations belongs wholly to my *alma mater*.

The sole intent of this specific school, the history of which I have sketched, was, as you all know, the thorough equipment of *mining* engineers and metallurgists. But the idea in the minds of the trustees, when they gave it their sanction and encouragement, was much broader than this. In acknowledging a gift of minerals from Mr. Gouverneur Kemble in September, 1864, the trustees directed "that he be informed that arrangements are now in progress for establishing, *as a portion of the post-graduate instruction in the college*, a school of mines and metallurgy." And again, in an early official circular they say:

"The necessity that exists for more fully developing all the material resources of the country has led the trustees of Columbia College to take measures for establishing a *school of applied science*. . . . . As a *first* step in this direction, the trustees are organizing a school of mines and metallurgy." The organization of this school was, in fact, but the carrying out of a design formed some years previously by the trustees, as is apparent from a resolution adopted in June, 1859, "that the committee on post-graduate instruction report to this board, at its next meeting, on the expediency of establishing a *practical school of science*."*

* It may be of interest to note, in this connection, that the trustees' Committee on the Course, after having deliberated upon the matter more than three years and made upon it several well-considered reports, submitted to the trustees, March 2, 1857, a statute for modifying and extending the undergraduate course and for organizing a "supplemental or post-graduate course of study." The proposed statute was printed; on May 11, it was considered in committee of the whole and amended; on July 6, it was further amended and, as amended, adopted. After prescribing an extended and very liberal undergraduate course, the statute provided further:

"OF THE UNIVERSITY COURSE OF STUDY.

"Lectures shall be delivered in the college which shall be conducted in three distinct schools. They shall be open to any person, under such regulations as the trustees may from time to time prescribe.

"1. A school is established, called *The School of Letters*, in which shall be pursued the following studies:

"Moral and mental philosophy, including an analysis of the moral and intellectual powers: æsthetics, or the principles of taste and art; the history of philosophy; appropriate literature of the Greeks and Romans; oriental and modern languages, as far as possible; comparative philology; ethnology.

"2. A school is established, called *The School of Science*, in which shall be pursued the following studies:

"Mechanics and physics; astronomy; chemistry and mineralogy; geology and

The records of the trustees, which I have recently examined, show that the question of enlarging the scope of instruction has been ever present with them. For the greater part of the entire period covered by the history of the college, they have proposed schemes in this direction; they have usually been in advance of the community, which has never supported them as it should—they have really been leaders in educational thought and action. Their official proceedings abundantly prove this, but I have not now the time, nor is this the place, to set it forth properly. The design of a school of applied science, of which the School of Mines was to be the first instalment, has been realized more completely, perhaps, than any other which the trustees had previously projected. The original school soon enlarged its boundaries, and has become a school of civil engineering, of applied chemistry, of geology, of architecture, of sanitary engineering. It *is* a school of applied science, as it was intended to be, though the name by which it first became known, and which really belongs to but one of its courses, has so endeared itself to us all that we postpone, perhaps unwisely, the inevitable time when we shall have to change it.

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palæontology; engineering; mining and metallurgy; arts of design; history of science; natural history; physical geography.

"3. A school is established, called *The School of Jurisprudence*, in which shall be pursued the following studies:

"History; political economy; political philosophy; the principles of national and international law; civil and common law; the writings of the Greeks and Romans, and of the modern civilians and jurists, appropriate to the last three subjects.

"The conjunction of the above three schools shall form the University Course.

"Any person who may enter either of the said schools may receive the degree of master of arts, after having pursued for a space of time not less than two years, to the satisfaction of the trustees and faculty, such of the studies thereof, and under such regulations, as the trustees may from time to time prescribe.

"There shall be fellowships, with or without stipends, to be filled by the Board of Trustees, upon such examination, and upon such rules and regulations, as may hereafter be prescribed.

"There shall also be prize scholarships in the sub-graduate course under proper regulations."

A full execution of the statutory scheme was not attempted for want of the requisite funds. In the fall of 1858, a post-graduate course, less extensive than that indicated, was, however, opened, and lectures were delivered therein by distinguished men; but the time seemed not to be ripe for the proper support of it by the public, and it was relinquished after one year's trial. The present law school was an immediate outcome of that tentative university course; and all that the college has since done in the way of expansion seems to have been in furtherance of the plan contained in the statute of July 6, 1857.

The school has proved itself of distinct public advantage. It has been of service to the cause of secondary education, in that it has, by its exactness and its requirements, done much to improve the methods and enlarge the scope of preparatory schools; and has aided the cause of university education, in that it has stimulated a desire for scientific research, and has maintained, from an early date, advanced courses in pure as well as in applied science. When it was begun, the first of its kind in the country, there was scarcely any such thing as the science of mining adapted to American needs. The school did much to supply it. Said a writer in the *North American Review* for January, 1871, speaking of our School of Mines: "The literature of the mining profession in the English language is very imperfect, and it was impossible to conduct the school in any other way than by lecture. . . . . This necessity is far from being a disadvantage. The lectures delivered in New York have the value of original examinations into the sciences they discuss, and when they are published, as is to be hoped they will be in good time, the body of mining science, as contained in American text-books, will be very different from that possessed by any other country."

Through the demonstrated excellence of the engineers it sent into the field, it was instrumental in breaking down the wall of ignorance and conceit which enclosed the "practical miner" and destroyed one-half the value of the output of a mine. Said the writer just referred to: "Commissioner Ross Browne, in his report on our western mines, [1871], says that experienced investors in mining property will not pay for a mine more than two and a half times its yearly profit. That is to say, they do not consider it a safe investment unless it returns *forty per cent.* upon its cost. The reason of this is plain. With no means of educating miners to their work, the conduct of mines in this country is a lamentable story of mismanagement, energy wrongly directed, and consequent great loss. . . . . It was difficult to introduce even the thinnest entering wedge of common sense into this hard prejudice against skill and study. For a long time the miners refused all help from schools or scholars, but the experience of continual trouble with their ores, and the gradually developed fact that they often lost more than they gained, have worked a complete revolution."

The "entering wedge of common sense" was largely due to this

school, which the writer declared had, in 1871, "already become one of the best schools in the world—more scientific than Freiberg, more practical than Paris."

What I have quoted from the *North American Review* was written of this school eighteen years ago. Since that time, mining has lost something of its relative importance, and the school, while still pursuing with the same care and with such modifications as experience has suggested, the course in mining and metallurgy, has, from time to time, undertaken new obligations in the establishment of additional courses of study. It may be said that, in each of its newer fields, it has accomplished results as gratifying and significant as those just recorded. In all its departments, the school has bred, and continues to breed, men, well trained, self-reliant and reliable men, men who their duties know and, knowing, so discharge, that their services are largely and continuously in demand as teachers, chemists, geologists, metallurgists, engineers, architects. The office and officers of the school have become a recognized supply department for professional men of character on the lines here laid down. I asked the secretary of this association, who receives many of the applications made, to furnish me with memoranda on this point. He has quite overwhelmed me with information. He has given me a long list, too long to be read here, of "positions held by graduates, taken at random." The list includes positions of great responsibility in various parts of the world, in China, Japan, Russia, Austria, Germany, England, Canada, Australia, Cuba, throughout Central and South America, and in most of the States and Territories of the American Union. He concludes his suggestive communication as follows:

"I have now on my books the following places for which I desire to find men:

"Analytical chemist to take charge of laboratory in Pittsburgh, Pa.

"Assayer in Costa Rica.

"Assayer for a mill in Washington Territory.

"Professor of metallurgy at Madison, Wis.

"Manager for blast-furnaces in New Jersey.

"Chemist for furnaces in Youngstown, O.

"Surveyor for coal mines in Alabama.

"Superintendent for a mining company in South Africa.

"In all the positions mentioned the salaries range from $1200 to

$10,000 per year, and a number of those mentioned receive at least $5000. Places worth $8000 have recently been refused by three graduates to whom they have been offered."

As a sample of the letters received by him he gives the following:

"I may say that the appointment of Mr. ———, whom you selected for the Darien Gold Mining Co., Ltd., having proved so successful, is one reason why I venture to apply to you again.

(Signed) "R. H. HEENAN,
"Manchester, Eng."

And how is it that results so creditable to the college and so beneficial to the public have been brought about? The school cannot create genius, but it can build character, develop and make effective native ability. This it has done by having, in each of its courses, a definite aim, and by seeking to attain it by absolute fidelity and singleness of purpose. Each of the courses has been laid out with the utmost care, so as to include what is essential and to exclude what, however desirable in itself as a branch of knowledge, may yet be dispensed with. This is a matter of fundamental importance and of no small difficulty. It is impossible to teach here, or in any other institution, everything desirable for a professional man to know. Something, very much, must be left to the man himself. All that can properly be done is to give thorough instruction in subjects that are far reaching in their applications—such instruction as will enable a graduate to do the great variety of things connected with his profession which he will necessarily be called upon to do, but which cannot be precisely foreseen or, if foreseen, cannot be specifically provided for here. In other words, the school should seek, as it has always sought, to make *thorough* scholars, equipped with fundamental principles and the knowledge requisite for their proper application, and thus fitted to adapt themselves to new conditions as they may arise, to make themselves familiar with or to devise new processes, etc., etc.—and not attempt to make *finished* scholars (which it could not do if it would), or sciolists who, in attempting too much, have, as their chief acquirement, a descriptive familiarity with professional methods and appliances that are in vogue to-day and may be superseded to-morrow.

The school has, of course, its limitations. It cannot, in any of its courses, require too many things, or give undue prominence to any one. It cannot, without injury, allow the intrusion of special

lectures, however instructive and valuable in themselves they may be, to the disturbance of the regular, persistent attention of a student to the prescribed and essential studies of a course. Time is limited and so is the endurance of a student. The title-rôle in each of the courses must, in the nature of things, be the one most prominently set forth, and all else must be made subsidiary to it. In no other way can thoroughness, and consequent professional excellence, be assured; in no other way can the school continue its success and enlarge its usefulness. Hereafter, as hitherto, when a new course is arranged, as doubtless such will be, it should be arranged solely with reference to the specific object in view, with reference to solidity of professional acquirement rather than the meretricious appearance of it. *Non multa sed multum*—not many things but much—should be the legend over the entrance to each of the professional courses. In these days of pedagogic unrest, when, to a part of the community, everything educational that is, in this country, is wrong; when plausible discourse on the theory, is too often more highly considered than intelligent activity in the practice, of educational methods; it behooves a school like this to "prove all things, hold fast that which is good," that which common experience, the necessities of every-day professional life approve, and not be led away by glittering generalities and doubtful assumption to attempt a short cut, a royal road, to the region of higher professional attainment. As before remarked, the school cannot teach everything of technical value in four years. This has been recognized from the beginning, and from an early period, facilities have been afforded here to graduates who, having learned one practical application of their knowledge, may wish to acquire another, or who may desire to pursue a selected subject further than undergraduate necessities will permit. While it is true that advanced courses of study have always been maintained, that admirable work has been and continues to be done in them, and that theses written for the doctor's degree have, when published, proved valuable additions to the sum of human knowledge, it is also true that such courses might be more liberally encouraged. They might, with advantage, be amplified and made more conspicuous; they might be open to graduates not only of our own school but of others of like grade and standing and, under suitable restrictions, to professional men who, having graduated from no school save that of experience, may wish to supply their ascertained defects, or study some new

development. A beginning is to be made in this direction, in the matter of electrical engineering. There is, perhaps, no applied science that has advanced with more rapid strides of late years than this. An enormous industry has grown up, by itself as it were, like a mushroom in the night, involving the most subtle and most powerful of natural agencies, and yet, as a branch of engineering, it has received but scant recognition from educational institutions. It speaks well for the fundamental training of graduates of this school that many have applied themselves to it with success. Next October, a course in electrical engineering will be opened, under the general direction of the professor of engineering and in the immediate charge of two excellent young men, graduates of the college; one of them, Mr. Crocker, of the class of '82 School of Mines, who has devoted himself to the subject ever since his graduation and has an acknowledged position in the profession, will teach the practical applications of electricity in all its branches; the other, Mr. Pupin, of the class of '83 School of Arts, who for three years filled the John Tyndall Fellowship for the encouragement of research in physics and spent his time in the laboratory of the great Helmholz, will give instruction in the theoretical branches of mathematical physics as applied to electricity, in the various relations to heat, magnetism and energy or power. The course is to be one for graduates of our own and other schools of like grade and standing. It is probable, also, that non-graduates of sufficient age, who can give to the faculty satisfactory evidence of adequate preparation, may be permitted to take a partial course not leading to a degree. It is further probable that, in the near future, a building will be erected for the accommodation of this course and to give additional facilities for investigations in metallurgy.

This is conservative, natural, development. The success of the scheme will assuredly invite its extension. The whole subject of graduate instruction and the relation of the school to it is now under consideration by a special committee of the faculty. That committee has already made a partial report, as to electrical engineering; it will, doubtless, early in the coming year, make a further report, treating more generally of higher scientific courses. From the beginning of the Graduate Department of the college in 1880 till now, all the instruction in pure science therein given has been given by professors of this school. In the fuller university development that is coming on apace, there is no reason why this

school, not the least of the educational glories of Columbia College, should not be the acknowledged, as it is the real, representative of pure as well as of applied science. There is every reason why it should have the direction and control, under the trustees, of the advanced scientific studies for university degrees. And in the contemplated publication by the college of meritorious papers by officers and graduates of the college in all its departments, it may well happen that the excellent journal conducted under your auspices, which is read in many parts of the scientific world and quoted in the scientific press—THE SCHOOL OF MINES QUARTERLY—will take upon itself enlarged responsibilities and become of increased usefulness.

In conclusion, gentlemen, I congratulate you and felicitate Columbia College on the past history, present condition and future prospects of the School of Mines. In the larger field, which it appears to be entering, as a Graduate School of Applied Science, a University School of Pure Science, I hope and believe that it will not abate one jot or tittle of its exceeding care and thoroughness in the courses which it now conducts, and will continue to be, in greater and greater degree as its scope widens, a beneficent and potent agent in the dissemination of sound scientific learning, of solid professional acquirement, of skilled methods in developing and utilizing the material resources of nature, of new scientific truth, and, through the high character of its graduates, of all the influences that tend to improve the art of living and elevate mankind.

"FUEL OIL" FOR STATIONARY BOILERS IN NEW YORK CITY.

BY H. F. J. PORTER, M.E.

I TAKE pains to make the title of this paper specific that I may not mislead the reader to suppose that I am going to review the more extensive and general subject of liquid fuel.

I have just had occasion to look into the question of introducing oil as a fuel under our own boilers, and as reliable information for the solution of the problem, as here presented, of relative economy

between coal and oil was not readily attainable, I have thought that I would place my efforts in this direction in such form that others similarly situated may gain what profit they can from it.

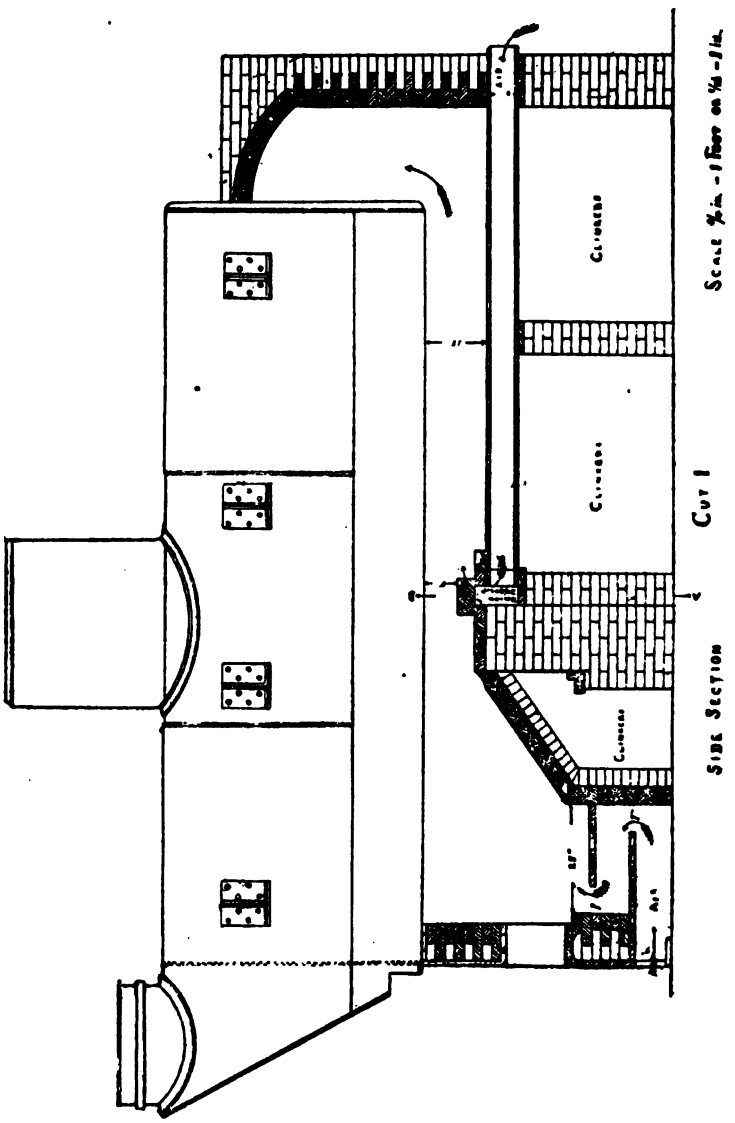
To those who wish to consider the present status of the liquid fuel question, I would recommend the papers and discussions of the National Electric Light Association, presented at its meeting at Chicago in April last, and printed in all the scientific journals at the time. There is also a most exhaustive paper on the special subject of burning oil under locomotives by Dr. Charles B. Dudley, printed in the *Journal of the Franklin Institute* of August, 1888. This paper is the result of Dr. Dudley's tests for the Pennsylvania Railroad, and is very interesting reading. In it he incidentally describes his visit to Mr. Thomas Urquhart in Russia, gives the details of the system of burning oil under locomotives there, and is most graphic in his account. The reader of this paper will envy this down-trodden nation at least its railway travel, free from noise and dust of any kind.

At the outset of our consideration of the change from coal to oil, we find that there are in the market two distinct kinds of oil fuel. One, the product of the Ohio and Pennsylvania oil-wells, known in the market as crude petroleum, or more specifically Lima oil, as most of it comes from the town by that name; the other, "fuel oil," a distillate from the oil refineries. No process has, as yet, been discovered for the satisfactory and economical refining of either of these products for illuminating or lubricating purposes, and they are sold to the gas companies, the asphalt paving companies, and as a refuse for burning.

Lima oil is lighter than fuel oil, is quite volatile, and has a very disagreeable odor. On account of this latter characteristic and its inflammable qualities, its use in New York city is prohibited by the Board of Health and the Fire Department. We are not, therefore, called upon in this paper to consider it further, but will turn our attention to "fuel oil," the only alternative if we wish to change the type of our fuel from solid to liquid.

We find the control of "fuel oil" in the hands of the Standard Oil Company, which has a special department devoted to its interests. Now, let us see what it is which they offer to us as a substitute for coal. After the oil refiner has extracted from the crude petroleum whatever he can dispose of in the shape of naphtha, refined oil, tar and paraffine, he obtains a distillate

which is a thick, heavy, green-colored oil. The sample which I obtained from the refinery of the Pratt Manufacturing Company



had a specific gravity of 0.818 or 40° Baumé at 60° F. temperature. It had a flash test of about 218° F. One gallon weighs 6.81

pounds. Its analysis, as made by Dr. C. E. Colby, School of Mines, is

	Per cent.
Fixed carbon,	85.334
Hydrogen,	13 525
Oxygen and impurities,	1.151

Its market price at present is $1.47 per barrel of 42 gallons, or .035 per gallon, or .005 per pound.

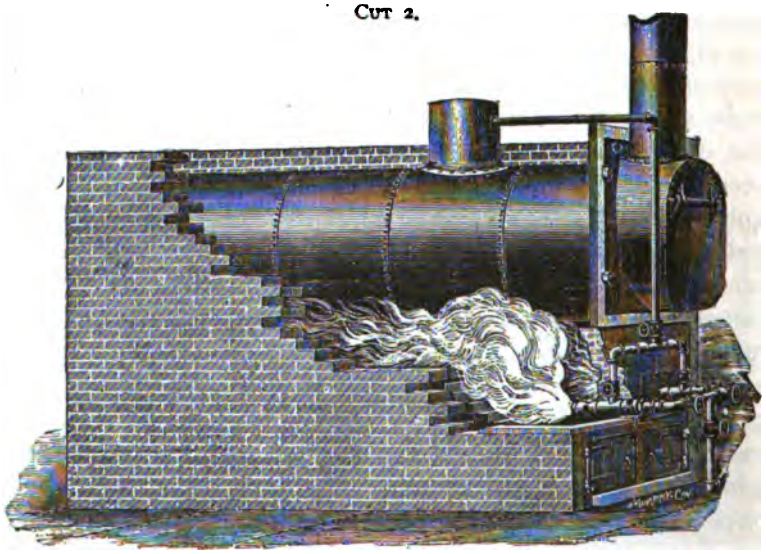
Cut 1 shows an ordinary horizontal tubular boiler as arranged for "fuel oil." The following directions for resetting a boiler 16 feet by 5 feet 6 inches, are those recommended by the Star Burner Company, of Cleveland, Ohio, and have given great satisfaction. They may be changed as circumstances require.

" Remove grate bars and ash doors, build a ' break or combustion wall ' from floor up to level of bearing bar, 4 inches thick and 32 inches distant from front wall, make an incline from this to meet top of old bridge wall; filling the space between these walls with broken stone or clinkers. The angle of incline between these walls should be as near 45° as possible. Should it occur that the distance between the walls is too great to permit of this, accomplish it by making the angle of 45° from front wall, thence going back in a straight line to top of old bridge wall. This wall and incline should be faced with the best fire-brick and well cemented. Narrow your fire chamber the whole depth and length, and make bed from hollow bridge wall back with ashes or clinkers, leaving space of 16 inches between it and bottom of boiler. Erect an 8-inch wall in rear of and against the old bridge wall to within 23 inches of bottom of boiler; upon this construct a hollow bridge wall with space of 5 inches; cover this with brick laid edgewise 4 inches apart. The distance between the upper side of these brick and bottom of boiler will be about 8 inches. Construct two 6-inch air flues, beginning at the back wall, extending to and connecting with hollow bridge wall, running them parallel to and 15 to 18 inches from the side walls. They may be made of fire-clay or iron pipe; if the latter, a covering of ashes or clinkers to the depth of 2 inches will form a protection. Two 8-inch piers should be placed midway from bridge and back wall to support these flues. Build two air flues in front in ash pit about 10 inches apart, with an upper return. Use fire-brick standing on end and 5 inches apart, cover flues over with split brick, leav-

ing open space of 7 inches at back end of lower and front end of upper section. The upper portion should be built entirely of split brick and the whole thoroughly cemented. The ash pit should then be filled with ashes to a level with lower section. The air passing through all these air flues becomes greatly heated, that in rear flues reaching 800° to 900° F., and that in front 408° to 500° F. at point of delivery. The firing place and ash door openings should then be closed entirely. Dampers may be placed on air flues to assist in regulating supply. In using ashes, care should be taken to have them as free from coal dust as possible."

It may not be necessary to remove the grate bars, and some boilers are arranged with fire brick laid on top of the bars to protect them from the flames. Under such circumstances a return to coal may be made at any time at short notice.

CUT 2.

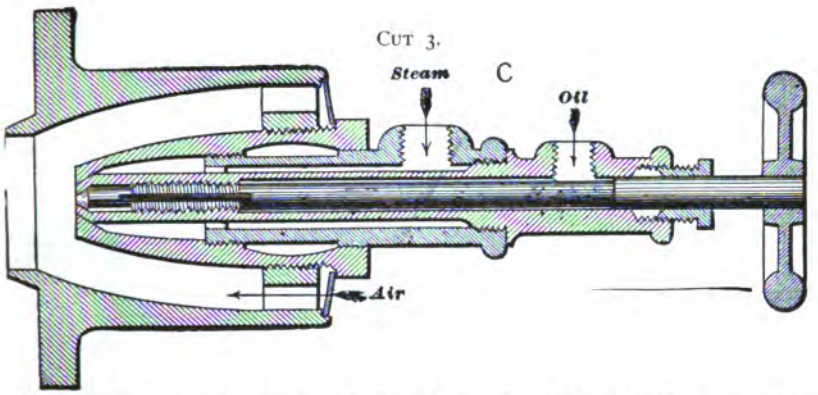


Cut 2 gives the appearance of the burner in operation. A section of the side wall of the boiler setting has been removed that the flames may be seen.

Of burners, or atomizers, as they are often called, perhaps that shown in cuts 3 and 4 is one of the best type. It is known as the "Burrell burner," and is furnished by James Naylor, Poughkeepsie, N. Y. A hole is bored through the furnace door of the boiler, and the nozzle of the casting is fitted into it. The flange

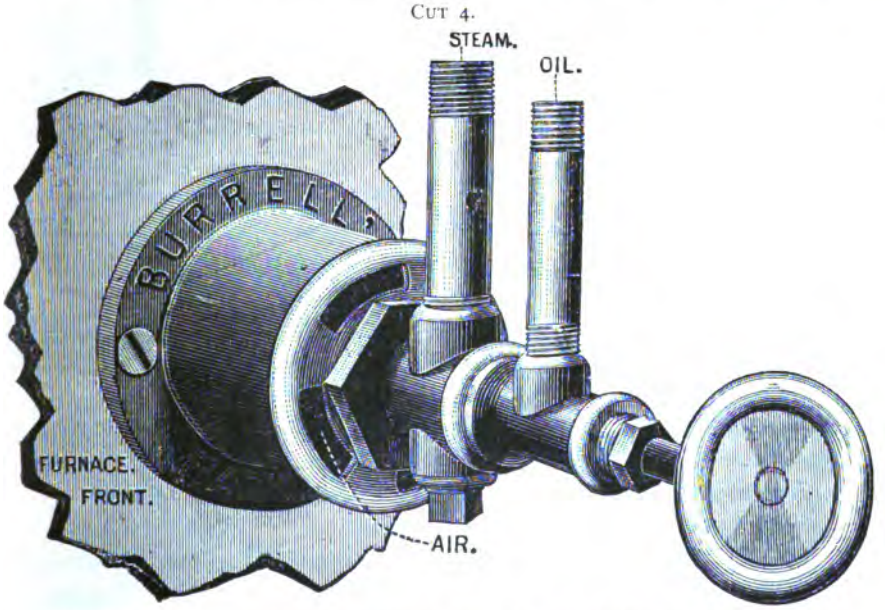
is brought close against the door, and is bolted securely to it. A steam-pipe is run through the furnace and then connected to the

CUT 3.



burner at the point designated in the cut. The object of running the pipe through the furnace is to insure a supply of perfectly dry steam by super-heating it. The oil is supplied at the inlet shown.

CUT 4.



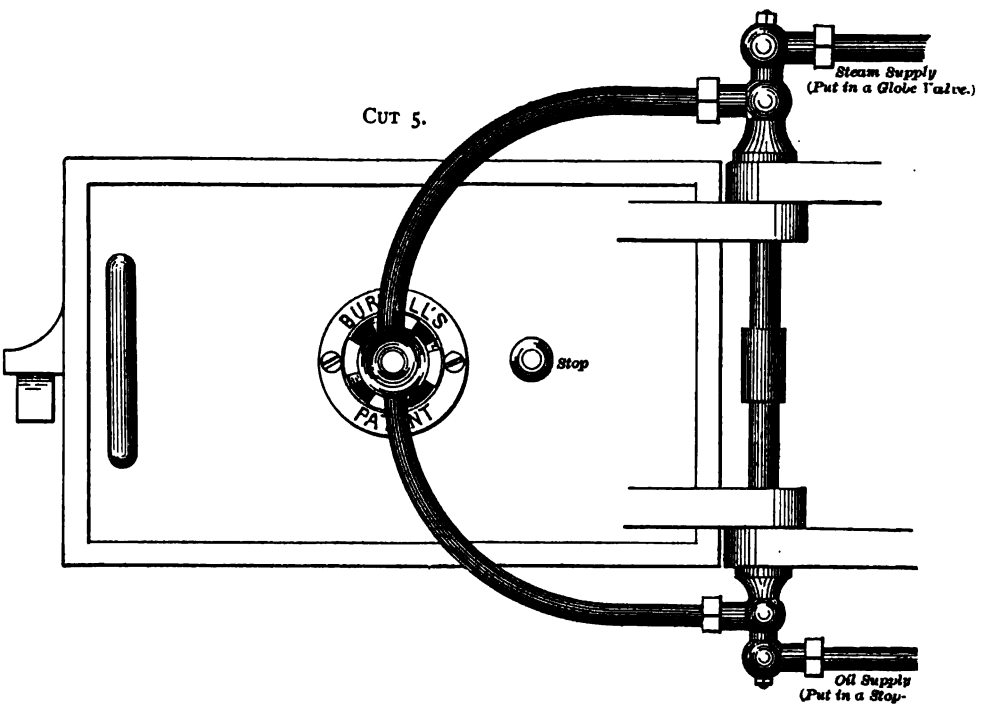
The size of the annular aperture can be regulated by the handle, and the supply of steam and oil governed accordingly. It will be seen that the atomizer works on the principle of an injector, draw-

ing in the oil and air for combustion by its inertia. The oil enters the furnace in a finely divided spray, the form of which is very similar to that made by the small cologne atomizers sold at druggists, except that it is about 6 feet long by 4 feet in diameter.

Cut 5 shows an ingenious method of connecting the pipes to the burner, thus enabling the door to be opened for the purpose of cleaning the burner and for access to the furnace.

The insurance companies have been very rigorous in allowing

CUT 5.



policies on buildings where oil is used as fuel, and it is only under certain restrictions that they will allow them.

The Associated Factory Mutual Insurance Companies of Boston have issued the following special report, and all well arranged "fuel oil" plants are now made in accordance with its provisions.

"The hazards attending the use of petroleum as fuel are largely of a controllable nature, and are dependent almost entirely upon the precautions taken in regard to its storage and use.

"The tanks should be of iron, placed upon solid foundations,

and fitted with tight covers provided with ventilating pipes for the removal of any vapor passing off from the oil.

"The tanks should be situated where they will not constitute an exposure to the buildings in case of fire. It is very desirable that the main tank at least, if above ground, should be surrounded by a dyke or embankment, inclosing a space sufficiently large to accommodate the whole contents of the tank without overflow.

"There should be two tanks; the main tank being placed where it could receive the supply discharged from the tank-cars by gravity, whence it may be pumped into the smaller or distributing-tank which feeds the oil directly to the burners.

"An overflow-pipe in the distributing-tank should be placed so as to discharge any excess of oil back into the reservoir-tank.

"Pipes should be placed underground as far as possible; the various connections should be supplied with valves for cutting off the flow of oil when desired.

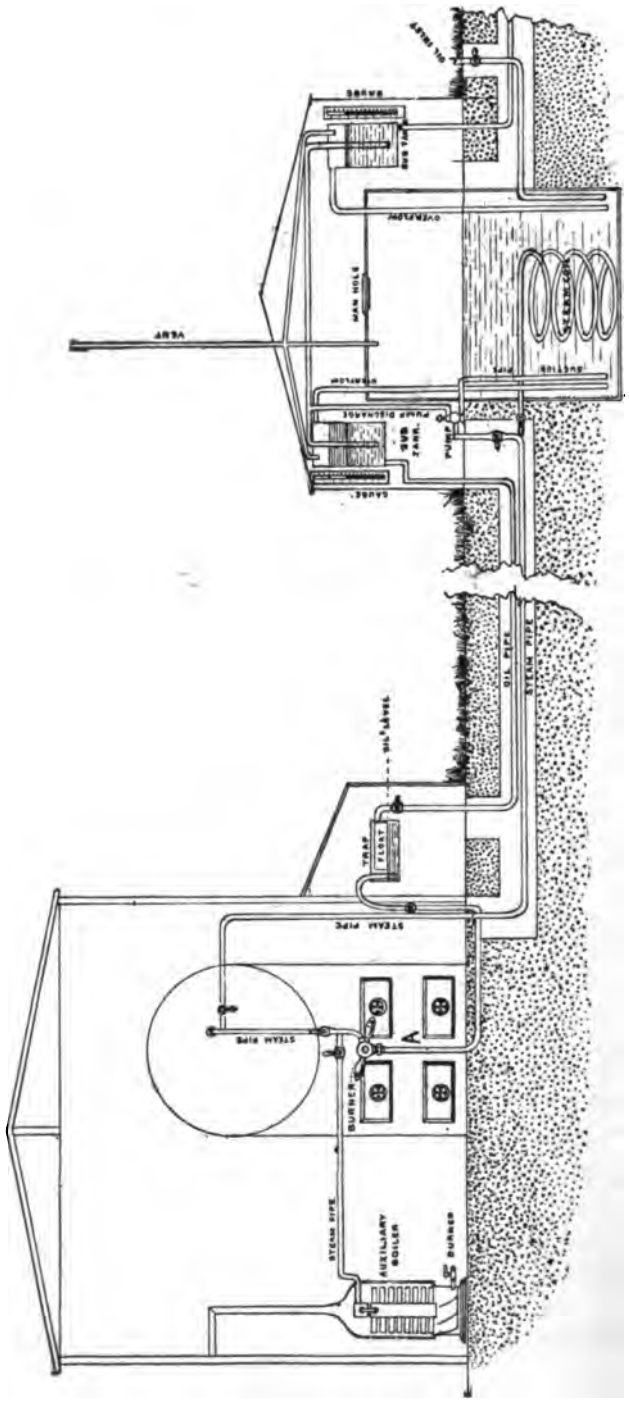
"If the oil is admitted to the burners before a flame is placed in the furnace, flashes or explosions are almost sure to follow, and it is absolutely necessary for safety that a burning torch or other flame be placed in the furnace before the oil is let on to the burners.

"The above requirements may be modified as needed, according to the circumstances pertaining to the use of oil fuel for metal working and other purposes."

Cut 6 shows a plant ready for working as arranged by the Racine Hardware Company, of Racine, Wis. It represents the arrangement of the plant at their works, and shows really two distinct boiler plants connected with one supply tank.

It will be seen to consist of a tank placed under ground and out of doors. From this a pump forces the oil to a smaller tank, whence it is supplied to a regulating-trap shown in section in cut 7, From this it passes to the burner. A small auxiliary boiler is shown at the left for starting the fire, for in order to make the burner work, a pressure of 50 pounds is necessary. The auxiliary boiler is provided with a small hand air-pump, with which to supply its burner with air instead of steam. After five or ten minutes, sufficient steam will be generated to dispense with the air-pump, and the plant can be used until sufficient steam is raised in the large boiler to run its own burner, and then the auxiliary boiler is shut down.

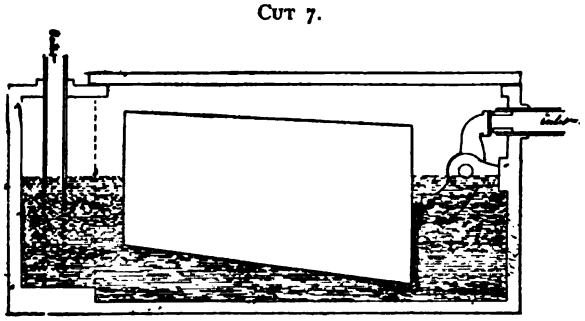
The trap is placed so that the oil contained in it is at the same


STEAM PIPE
TRAP
FLOAT
GAUGE
BURNER
AUXILIARY BOILER
STEAM PIPE
OVERFLOW
MAN HOLE
VENT
PUMP
STEAM COIL

CUT 6.

level as the burner; the oil then enters the latter without pressure due to weight, and the amount entering the furnace is regulated by the steam which draws it with it. This trap (Cut 7) contains a float arranged on the inlet-pipe, like a ball-cock, so that when the oil level is reached, the supply will be cut off by the float rising and closing a valve. There can, therefore, never be an overflow. Each trap is supplied with a strainer, through which all the oil must

CUT 7.



pass before reaching the discharge-pipe. The depression in the bottom of the trap is for the accumulation of sediment, which with water accumulation can be drawn off through a cock.

A fuel-regulator is so arranged on the steam-pipe leading to the atomizer, that as the pressure rises or falls, the supply-valve is closed or opened, thus governing the amount of oil entering the furnace, and a constant steam-pressure is thereby maintained. Should this regulator be closed, and the flame extinguished by a sudden rise of steam, due to closing down of engines, etc., as soon as the draught upon the boilers is renewed, the regulator again opens and oil is ignited by the red-hot fire-bricks within the furnace.

The following are a few of the leading burners now in the market.

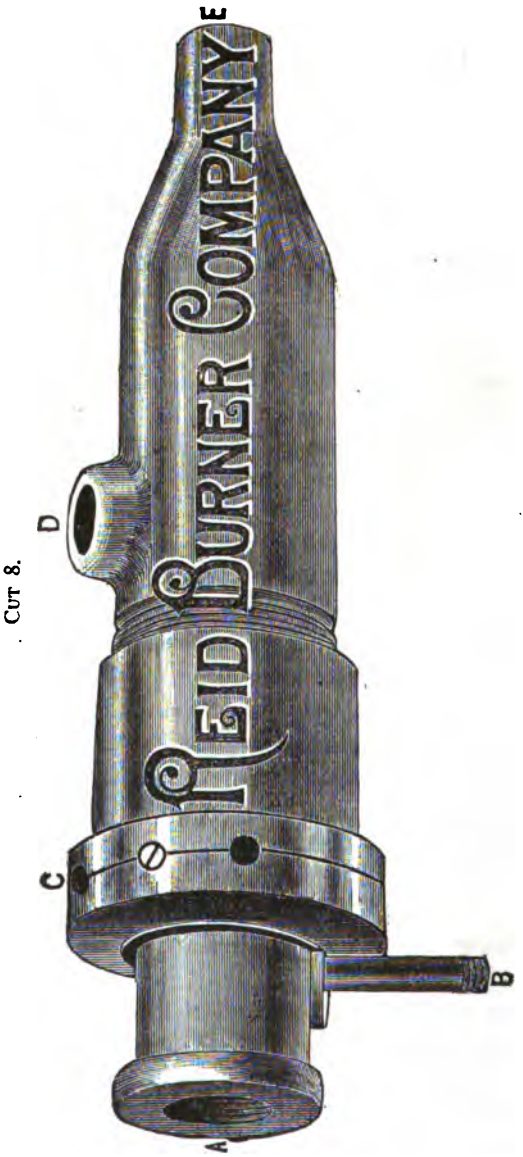
Cut 8 shows the type of burner furnished by the Reid Burner Company, of Cleveland, Ohio. A spanner fits the holes at C to regulate the supply of steam and oil. The burner of the Racine Hardware Company, Cut 9, is of the same type.

Cut 10 shows the Star burner, also of Cleveland, Ohio.

Cut 11 shows the burner of the Empire Hydro-Carbon Company of Exchange Place, New York.

The last two burners have valves on both the steam and oil pipes for regulating their supply independently.

Cut 12 (Figs. 1 and 2), shows the arrangement of the Whiting Oil-Gas Company of Philadelphia.

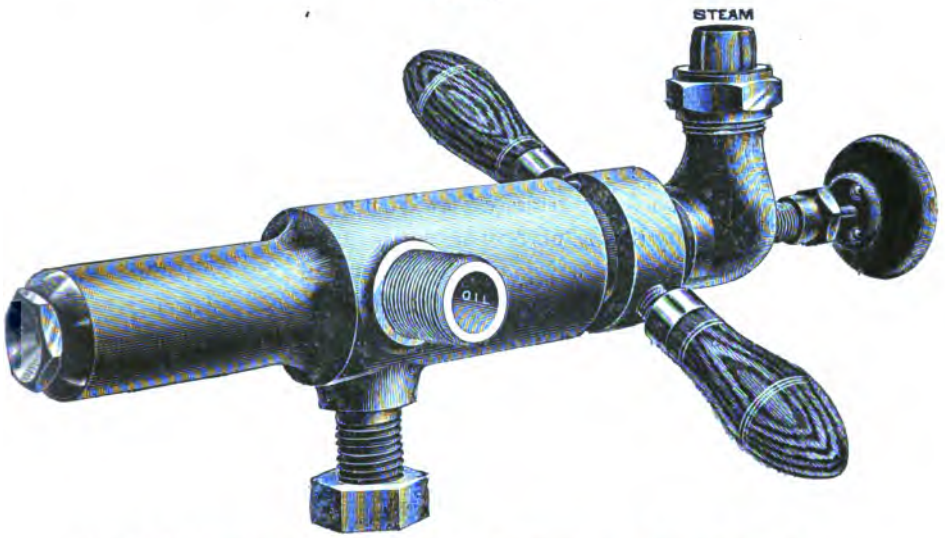


Cut 8.

In this system the oil-pipe is passed through the furnace with the steam, thus generating a permanent gas before issuing from the mouth of the burner.

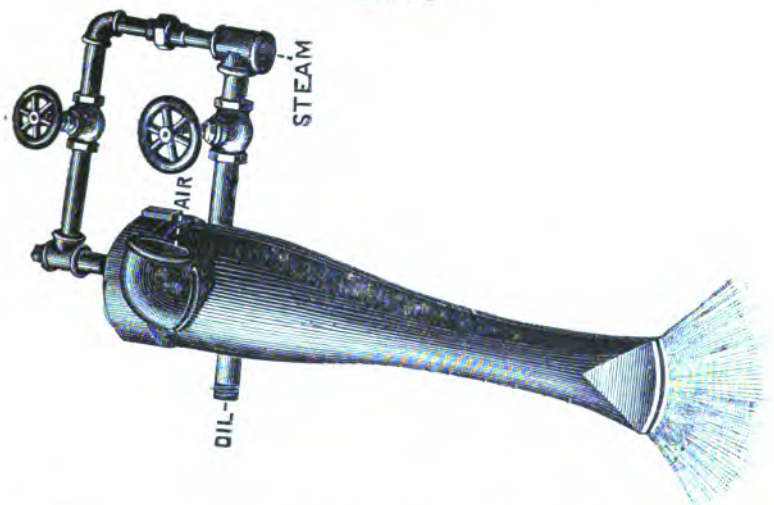
Before starting oil is allowed to run into the pan I I from the opening of the burner C, and thus the gas is generated in the pipe

CUT 9.



B, and the burner acts at once. The auxiliary boiler with all its attachments is therefore, by this system, omitted.

CUT 10.



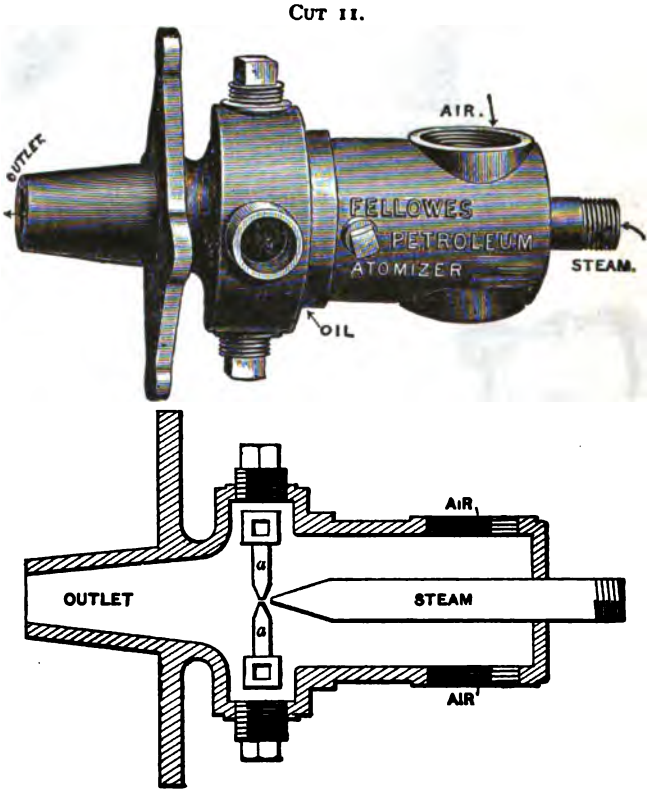
The system of the Archer Fuel Co. of New York is similar in its nature to this.

Cut 13 shows the form of burner and oil regulator of the Aerated Fuel Company, of New York. This system differs from all others in that air is used as an atomizer instead of steam. The latter, however, is necessary to run an air compressor to supply the necessary pressure to inject the oil into the furnace. I have not been able to discover that this system for use under boilers has any advantages over those using steam for atomizing; in fact, its projectors now advocate it principally for forge work where its advantages are manifest.

Cut 14 shows a forge arranged for burning oil.

It is claimed by the promotors of this system that a large amount of steam, and therefore fuel, is used by the steam atomizers; that the steam tends to quench the fire, and that the steam atomizer does not supply air sufficient to produce combustion. Let us consider this

Cut 11.

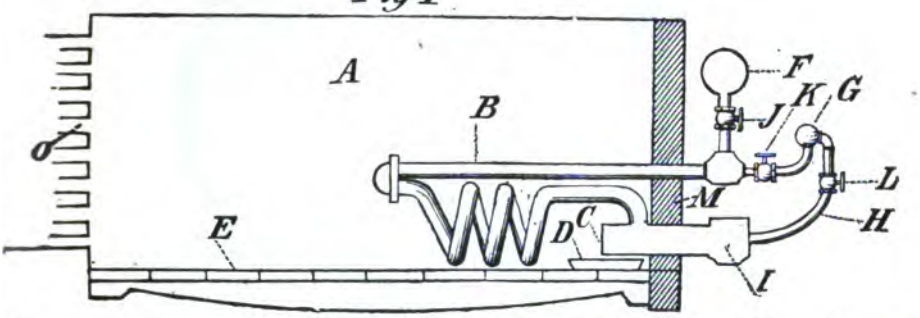


claim in passing. We have Rankin's formula $W = 6\frac{ap}{7}$ where

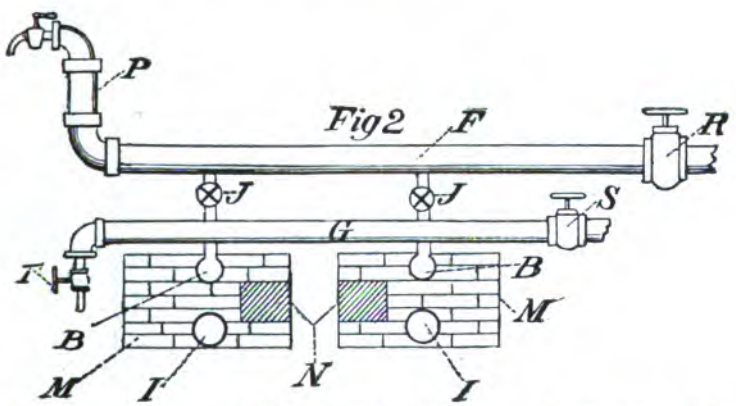
w = the weight in pounds of steam,
a = area of aperture,
p = absolute pressure.

CUT 12.

Fig 1



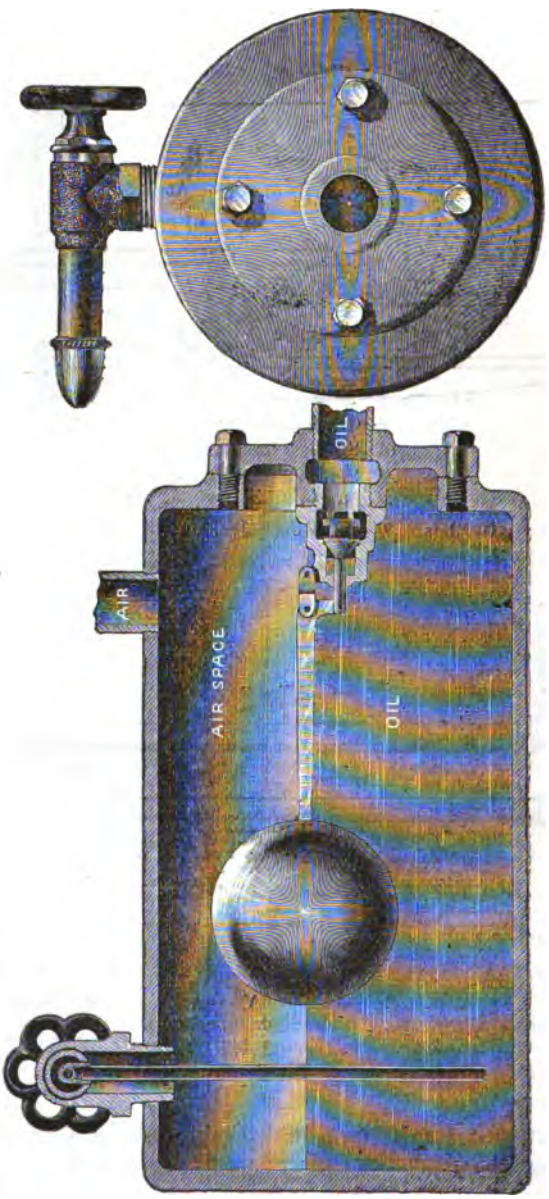
A—Furnace.
B—Gas Generator.
C—Burner.
D—Starting Pan.
E—Fire-Bricks covering Grate Bars.
F—Oil Supply Pipe from Tank.
G—Steam Pipe to Generator.
H—Steam Pipe to Burner.
I—Air Passage to Burner.
J—Oil Feed Valve.
K—Steam Valve to Generator.
L—Steam Valve to Burner.
M—Fire doors bricked up.
O—Tubes of Boiler.



B—Gas Generator.
F—Oil Supply Pipe from Tank.
G—Steam Supply Pipe to Generator.
I—Burner.
J J—Oil Feed Valves.
M M—Fire doors bricked up.
N—Openings into Fire-box.
P—Stand Pipe and Drip Cock.
R—Oil Supply Valve.
S—Valve to Steam Supply Pipe.
T—Drip from Steam Supply Pipe.

the amount of steam issuing at 85 lbs. pressure from the annular orifice of the steam atomizer of $\frac{1}{4}''$ area is but 4.2 pounds, or 18.186 cubic feet per minute, or 253.8 pounds water per hour, and the amount of oil necessary to raise this amount of water from 212° to

100 pounds absolute pressure, is a little over 10 pounds per hour, at a cost of $0.06, or $0.70 per day.



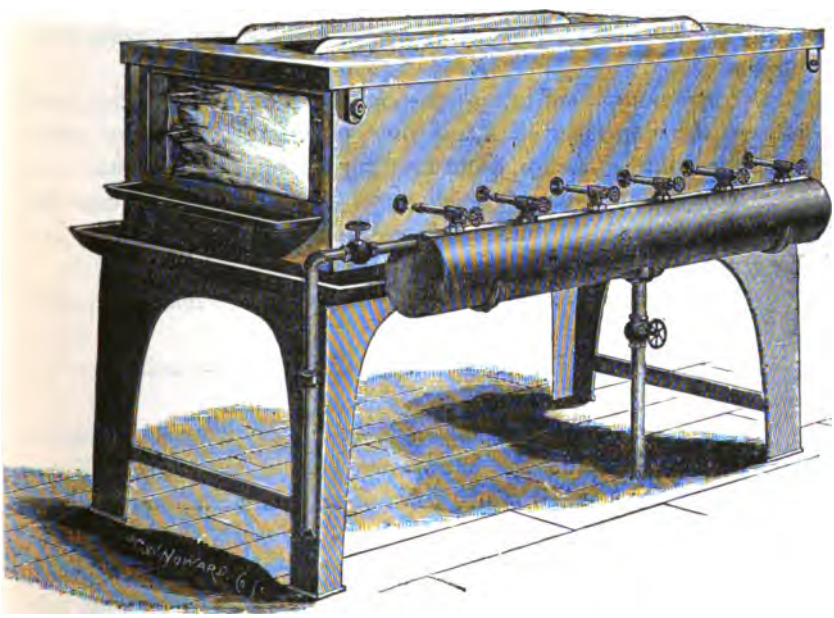
CUT 13.

There seems, however, to be some condensation of steam in connection with the oil, and when the flame is extinguished, parti-

cles of oil in the shape of fixed carbon adhere to the sides of the furnace, and these slowly burn. This is, to some extent, an advantage, and is used to ignite the oil when the jet is again turned on. It is used, also, as a "banked fire" when steam is let down for the night, or otherwise, and thus pressure is retained sufficient to do away with the necessity of starting the auxiliary boiler on such occasions. Air sufficient for combustion is supplied by the many vents made for the purpose.

The advocates of steam atomizers, on the other hand, claim that

CUT 14.



the steam is decomposed, by the great heat engendered in the furnace, into its constituents, oxygen and hydrogen, and that thus complete combustion is insured and the heating quality of the oil fuel is enhanced. They put forward no proof of this, however, and even if the change is produced it is accomplished by the expenditure of the amount of fuel necessary to produce the heat, and therefore nothing is gained. It will therefore be safe, in the presence of the unconsumed carbon in the furnace mentioned above, to consider this claim as invalid. The steam is therefore simply a diluent.

There is one objection to the use of all these burners. The rush

of steam from the orifice of the burners, particularly if there are many, produces a roar which is objectionable if the boiler house is situated where such a noise would be audible. It cannot, however, be said that the noise, although continuous, is louder than that produced in all boiler rooms by the handling of fire tools and quenching of ashes with water.

The advantages claimed for this fuel over coal are as follows:

1. *Less waste.*—Much coal is consumed in the form of gases, and there is great loss through the grate and in the form of clinkers and ashes.

2. *Economy in handling.*—The larger the plant the greater the economy; one fireman can easily tend a bank of ten or even more boilers.

3. *Economy in handling ashes.*—As there are no ashes the usual helpers are dispensed with and there is not the cartage of ashes which amounts with coal to at least 7 per cent. of its weight.

4. *Diminished repairs to furnace and grate bars.*—With coal the annual damages to furnace are large from the use of fire tools and the grate bars burn out and break frequently.

5. *Economy in cleaning boilers, engines, machinery and rooms, from the absence of smoke, dust and ashes.*

6. *Economy in repairs to ash pit and floors, from the absence of hot cinders.*

7. *Less waste of steam from safety valve.*—By the ease of regulating the supply of fuel the safety valve should never raise. There is said to be a waste of 5 per cent. of steam in stationary boilers through this outlet.

8. *Economy of wear and tear to boilers and steam plant due to constant and even steam pressure.*—The racking of boilers and piping due to uneven temperature is a source of great annual expense from broken fittings and consequent leaks.

9. *Economy in carrying and stowing fuel.*

10. *Economy in space for stowing fuel.*

11. *Absence of danger from sparks.*

12. *Possibility of utilizing more heat.*

13. *Relative economy.*

We will grant without question all of the above claims except the last, and this we will now consider more in detail.

Following is the analysis of our Lackawanna pea coal:

	Per cent.
Fixed Carbon,	83.268
Volatile matter,	4.381
Water,	3.421
Sulphur,	0.728
Ash,	8.203

The sum of the thermal equivalents of these various components gives us the theoretical calorific power of the coal to be 9939 thermal units.

The sum of the thermal equivalents of the components of the sample "fuel oil" is 11,555. We have therefore:

$$9939 : 11{,}555 :: 1 : 1.16$$

or 1 pound oil = 1.16 pounds coal; 8.62 pounds oil = 1 pound coal; 1 barrel of 42 gallons weighs 286 pounds; 1923 pounds oil = 2240 pounds coal or 1 gross ton.

We may therefore state the case briefly as follows: If we consider only the relative efficiency of the two fuels,

$$\frac{1923}{286} = 6.7 \text{ barrels of oil} = 1 \text{ gross ton of coal.}$$

If then we let P = price per barrel of oil and p = price per ton of coal,

when $6.7\,P = p$, coal or oil may be burned with equal cheapness.

" $6.7\,P > p$ it is cheaper to burn coal.

" $6.7\,P < p$ it is cheaper to burn oil.

There are, however, other factors which should enter the equation of economy of coal and oil burning, namely the ash cartage and help required to handle the coal and ashes.

Last year we burned 1325 gross tons coal at a cost of	$5475
Our total ash cartage was	325
The wages of help necessary to handle coal and ashes was	865
Total cost,	$6645

or a rate of $5.03 per ton.

The increase in expense due to handling coal over and above the market price is therefore 21 per cent. of its cost. In our comparison with coal we should therefore credit the oil with 21 per cent. more efficiency and change our ratio 1.16 to 1.37 and our figures will be changed as follows:

Let weight of oil per gallon = 6.8 pounds.

" number of gallons per barrel = 42 pounds.

Let ratio of oil to coal = 1.37 pounds.
" cost of coal = $5.03 per gross ton.
" cost of oil per pound = $0.005.

We have then $\frac{2240 \times .005}{1.37} = \$8.17$ = equivalent price of coal per ton and $\frac{5.03 \times 1.37}{2240} = .00307$ = equivalent price of oil per pound.

$\frac{1325 \times .005 \times 2240}{1.37} = 10{,}832.12$ = equivalent cost of oil if burned last year.

The cost of altering our boilers and of supplying tanks, piping, burners, etc., necessary for burning fuel oil, would have been about $1000, the interest of which at 5 per cent. or $50 should properly be added to the above amount. We have therefore:

Total expense, had we burned oil last year, ...	$10,882
Cost of burning coal last year, ...	6,640
A difference in favor of coal, ...	$4,242

The claim of relative economy is therefore by no means maintained. It would cost us 60 per cent. more to burn oil than coal.

We should, on the other hand, have the other benefits mentioned by those interested in promoting oil consumption. Our cellar, capable of holding 600 tons of coal, would become available for other uses. This amount of area representing a high ground rent is also a factor in favor of oil.

The Fire Department and the insurance companies had no objections to offer to the change if put in under the requirements of the companies herein mentioned. The tank cart of the Pratt Manufacturing Company would supply oil to our tank daily if necessary, the oil being fed into it noiselessly through a hose by gravity.

There is really everything in favor of the use of "fuel oil" except its present price. It is the old question—will we pay for a luxury? Until the oil refiners can reduce their price for this product its use must remain limited. The Oil Company says the output from their factories is small and is all taken at the present figure. There is at present little prospect of a reduction in price.

To those who have boilers under their care and have seen oil

used as a fuel or have seen the use of natural gas in the west, the inability to give up coal is a great disappointment. The man who makes his steam outside of the domains of the board of health and fire department is happy in his location.

To those who are similarly situated and desire to compare their figures with ours, I would remind them that they must consider the price of their coal delivered at the boiler door and include the disposal of their ashes. A substitution of their price of coal in the following formula will tell them at once if they can afford to make the change:

$$\frac{2240 \times \text{price of oil per barrel.}}{\text{Weight of oil per gal.} \times \text{number of gals. per bl.} \times \text{ratio of oil to coal}}$$

= price per ton of coal, which they must not exceed.

NOTE.

The New York Mathematical Society.

THERE are certainly enough mathematicians in New York to warrant the organization of a New York Mathematical Society, and it is somewhat surprising that only within the last few months such a society has been formed. This society has drawn its members chiefly from the faculties of the various colleges in New York and the vicinity. It has also obtained a number of members from the actuarial departments of the great insurance companies. Its object is to encourage original investigation and research. As its name indicates, it is to be representative of the city, concentrating its best mathematical ability. The meetings of the society are monthly, being discontinued, however, during the Summer. They have been held up to the present time at Columbia College. The first president of the society is Professor J. H. Van Amringe, of the School of Mines.

THOS. S. FISKE, *Sec'y.*

ABSTRACTS.

Analytical Chemistry, by E. Waller.

Potassium Manganate in Analysis. Jolles (*Rep. Anal. Chem.*, vii., 485).

The reagent is made by fusing together weighed quantities of potassic hydrate and permanganate. The material must be preserved out of contact with the air. It may be used in neutral solutions for titration of manganous salts, the precipitate of MnO_2 settling readily so as to permit the end-reaction to be seen, or of cobalt under the same conditions, in which case the precipitate is $CoMnO_3$.

Nitroso β Naphthol in Quantitative Analysis. Knorre (*Ber.*, xviii., 2728).

In acetic solution nitroso β naphthol precipitates Co, Fe and Cu, but does not precipitate Al, Pb, Cd, Ca, Mg, Mn, Ni, Hg, Zn, etc. To separate copper, the metals should be as sulphates or chlorides and in small bulk. Neutralize free acid with ammonia and acidify with a few drops of HCl. Heat to boiling, and add an excess of the reagent dissolved in 50 per cent. acetic acid; filter the reagent hot through a wetted filter into the boiling solution. Allow to stand some hours in the cold, filter and wash with cold water, till a drop of the washings gives no residue by evaporation on platinum foil. Heat the precipitate gradually, finally ignite and weigh CuO. Ag, if present, will be found with the CuO. Fe (ic) may be separated in the same way from Mn, Zn, or Ni, and in presence of a larger proportion of HCl (5 per cent.) from chromium, but not from Al. The iron precipitate is very bulky, and provision must be made accordingly. Phosphoric acid, if present, also comes down with the iron.

Phenolphthalein and Ammonia. J. H. Long (*Am. Chem. Journ.*, xi.).

Phenolphthalein can be used with ammonia, if the solution is kept cold, and a considerable quantity of the indicator is used.

Alkalimetric Titrations. Cross & Bevan (*J. S. Ch. Ind.*, viii., 252).

In examining commercial caustic soda with methyl orange as indicator, the neutral point was found to be at $2Al_2O_3 : 5SO_3$ or 1 c.c. of standard acid $= 0.0212$ instead of 0.01716 Al_2O_3.

A method for the titration of caustic soda containing carbonate, aluminate and sulphite is given.

Iron in Minerals. Johnstone (*Chem. News*, lix., 231).

A portion of the mineral is heated on clean platinum foil with about four times its bulk of KNO_3 or $KClO_3$. The heat is applied from below (Blp) the flame not being allowed to touch the mass. While *still*

hot, strong nitric acid is dropped (from a tube) on the mass, followed by a solution of potassium sulphocyanide. The test is so delicate, that care must be exercised in selecting reagents free from any trace of iron.

Standardizing Permanganate. Jahode (*Analyst*, xiv., 79).

The iron wire is dissolved in a flask with an exit tube leading through a solution of $NaHCO_3$. When the cooling draws a little of the solution over, CO_2 is generated, which drives out the rest of the liquid and keeps the ferrous solution from conversion to ferric.

Titration of Iron by Permanganate in HCl Solution. Reinhardt (*Chem. Zeit*, xiii., 324).

Free phosphoric acid as well as $MnSO_4$ are used. The solutions used are:

1. Standard permanganate, 6 grms. per litre.
2. 200 grms. $MnSO_4$ (+ few c.c. H_2SO_4) mixed with 1 litre phosphoric acid solution (Gravity 1.3) and 600 c.c. water with 400 c.c. H_2SO_4.
3. $HgCl_2$, 50 grms. per litre.
4. $SnCl_2$, 120 grms. Sn, dissolved in 500 c.c. HCl (Gr. 1.19) diluted to 1 litre and 1 litre HCl and 2 litres H_2O added.

Influence of Copper on Determining Iron in Ferro Alloys. T. W. Hogg (*Chem. News*, lix., 207).

If copper is present, on dissolving in HCl or H_2SO_4 and titrating with dichromate, the results are too high in proportion to the copper present, which does not dissolve until the oxidizing agent is added. By using $KClO_3$ in effecting the solution—reducing and titrating as usual, this source of error is avoided.

Rapid Determination of Si in Pig Iron. C. Jones (*Jour. Anal. Chem.*, iii, 121).

Drown's method is used. The evaporation is conducted in a platinum dish with a strong flamed Bunsen burner or a blast-lamp below, and another flame from a blast lamp above, the latter flame being directed downward upon the surface of the material in the dish. By this means the evaporation is effected in four or five minutes.

Separation of Zinc and Cobalt. Baubigny (*C. N.*, lix., 149).

In solutions acid with acetic, zinc can be separated with H_2S if the cobalt is not over 5 to 6 per cent. of the amount of zinc present. Where a little free sulphuric acid is present, the separation is unsatisfactory unless the cobalt is very small in amount, though when very little zinc is present fair results may be obtained.

Separation of Cobalt and Nickel. A. Carnot (*Chem. News*, lix., 208).

If H_2O_2 is added to an ammoniacal solution of the two metals, and then to this *cold* solution is added an excess of KHO, the nickel can

be completely precipitated as $Ni(OH)_2$, accompanied, however, by some of the higher oxide of cobalt. By resolution and reprecipitation twice more a precipitate of nickel practically free from cobalt is obtained.

Volumetric for Co and Ni. Carnot (*Chem. News*, lix., 183).

Solutions of the salts were boiled with alkaline oxidizing agents, the boiling maintained for a short time, the precipitates washed by decantation—finally on the filter. The available oxygen in the precipitate was determined by dissolving in dilute HCl, with addition of KI, decolorizing with decinormal hyposulphite, and titrating back with centinormal iodine and starch. The action of alkaline oxidizing agents was:

Reagent.	*Precipitate.*	*Color.*	*Precipitate.*	*Color.*
H_2O_2 and KHO,	Co_2O_3	Light brown,	$Ni(OH)_2$	Green.
(NaK)ClO,	$2CoO_2 . 4Co_2O_3$	Nearly black,	Ni_2O_3	Black.
Br or I and KHO,	$2CoO_2 . 3Co_2O_3$	"	"	"

In commenting on these results, McCulloch states that nickel precipitated by KHO and Br may vary in composition from Ni_3O_4 to Ni_3O_5. Also that H_2O_2 + KHO and boiling gives with Co solutions $Co_{13}O_{19}$ or some other oxides.

Volumetric for Nickel. T. Moore (*Chem. News*, lix., 160).

KCy is the reagent used in the ammoniacal solution of the metal. Decolorization is effected as with copper solutions, but without any addition the end-reaction is not sharp. It may be made so, however, by adding cupric ferrocyanide, *provided the excess of ammonia is not too great.* Solutions used: KCy, 22.5 grammes per litre, 1 c.c. = about 0.005 grammes Ni. Cu solution, 2.25 grammes copper sulphate in 1 litre. Add potassium ferrocyanide until no further precipitate is produced. Agitate before using.

Process.—The solution (sulphate, acetate, nitrate, or chloride) is rendered decidedly ammoniacal, the KCy added from a burette until the blue color disappears, then add a (measured) quantity of the Cu solution until it imparts a distinct color to the solution; then add KCy cautiously until one drop produces a distinct change of color.

It may be advisable to determine beforehand the amount of KCy necessary to decolorize 100 c.c. of the Cu solution and apply a correction accordingly, but for most cases, and with a little practice, fair accuracy may be attained without this.

Arsenic Pentasulphide. L. W. McCay (*Am. Chem. J.*, x., 459).

If air is excluded and H_2S passed under pressure, As_2S_5 is precipitated. An intermediate formation of H_3AsO_3S has been observed.

Ammonia Test for Mercury. G. S. Johnson (*Chem. News*, lix., 234).

The mercur-ammonium precipitate is readily soluble in ammonium carbonate.

Mercury in Minerals. Johnstone (*Chem. News*, lix., 221).

By heating the mineral alone (or, as may be necessary, with $NaKCO_3$ flux) in a tube closed at one end, a sublimate of mercury is formed which may be positively identified by exposure to iodine vapor, best generated in the tube by introducing a drop of conc. HNO_3 and then a drop of solution of KI. The characteristic scarlet mercury iodide could only possibly be confounded or else mingled with antimony or arsenic iodide. The first is brownish, the latter yellow. On heating, so as to volatilize a little of the nitric acid, the antimony or arsenic iodide is promptly decomposed while the mercury compound is much more slowly attacked. If the amount of mercury is very minute it should be caught on gold foil and the iodine test then applied.

Tin and Mercury. Welm (*Fres. Zts. Anal. Chem.*, xxviii.).

Stannic and mercuric compounds, when simultaneously present, are not separated by ammonium sulphide, a soluble compound of the two metallic sulphides with the ammonium sulphide being formed.

Examining an Alloy consisting of Lead and Tin. (*C. N.*, lix., 72), (*Jour. Pharm.*, xix., No. 1).

Dissolve in HNO_3, neutralize the excess of acid by dilute NaOH till slight precipitate of lead, add few drops of acetic acid to redissolve, and boil to separate insoluble stannic acid.

Reaction for Copper-salts. Deniges (*C. Rend.*, cviii., No. 11), (*C. N.*, lix., 168).

Convert to bromide by KBr. On dehydration by H_2SO_4, we get a fine violet-red color.

Determination of Tungsten in Alloys. Preusser (*Fres. Zts.*, xxviii., 173).

To effect solution of these alloys: Aqua regia requires five or six days; Schœffel's method, with cupro-ammonium chloride, is more rapid, but the analysis is complicated. The author shortens the time by roasting the pulverized and finely-sifted alloy until it becomes yellow, dissolves in aqua regia and evaporates once to oxidize any traces of tungsten, then evaporates two or three times with hydrochloric acid, finally heating to 120°. On filtering, a mixture of tungstic and silicic acids is obtained. This is mixed with three or four times its weight of sodium carbonate, and fused thirty minutes over a blast-lamp. After cooling and extracting with water, a second fusion of the residue may be necessary. Hydrochloric acid is added, and the solution is evaporated to complete dryness. Take up with water and allow to stand some time before filtering; wash with dilute NH_4NO_3. Dissolve the tungstic acid with ammonia, which leaves the silica. Evaporate the ammonia solution in a weighed dish, dry, ignite, and weigh as WO_3. If tin is present the method is the same, except that the residue after the first evaporation with aqua regia is heated to 120°.

Quantitative Electrolysis. Kohn and Woodgate (*J. S. Chem. Ind.*, viii., 256).

The following convenient table and references are given, together with description of apparatus, etc.:

I.	Nitric or sulphuric solution.	Ag[1], Cu[2], Cd[3], Bi[3], Hg[1], Pt[1], Pd[1], Zu[a].	Tl[1](as Tl_2O_3) Pb[1](as PbO_2), Mn[4], (as MnO_2).
II.	Double ammon.-oxalate.	Tl[5], Cu[1], Cd[b1], Bi[1], Sn[1], Pb[1], Pd[1], Co[1], Ni[1], Zn[1].	Al[1] (as $Al(OH)_3$), Mn[d1] (as MnO_2), Be[1] (remains diss'd $Be(OH)_2$), Cr (diss'd as $(NH_4)_2CrO_4$).
III.	Double ammon.-sulphate.	Ag[6], Fe[c], Co[1], Ni[1], Zn[11].	Mn[e11] (as MnO_2).
IV.	Double potass.-cyanide.	Ag[1], Cd[7], Au[1], Ni[11], Zn[8].	
V.	Sulpho.-salt.	Sn[1], Sb[1].	
VI.	In glacial phosphoric acid, after $(NH_4)_2Co_3$[10].	Bi, Cd, Sn, Fe, Co, Ni, Zn.	Al (remains diss'd) Mn[e] (as MnO_2) Cr (remains diss'd as chromate).

a. After adding $(NH_4)_2SO_4$ (Riche).
b. K salt preferable.
c. After adding $Na_3C_6H_5O_7$ and $H_3C_6H_5O_7$ (E. F. Smith, J. S. C. VII. 693).
d. Incomplete. Complete from double potassium oxalate.
e. Incomplete.

1. *Ciassen.* "Quant Chem. Anal durch. Electrolyse." Also Ber., xiv., 1622 and 2772, xvii., 2351 and 2467, xviii., 168, 1104 and 1787, xix., 323, xxi., 359 and 2392, also J. S. C. I., v., 344, vii., 401, viii., 137.
2. *Luckow.* Zeits. Anal Chem., 1869, 1.
3. *Smith and Knerr.* Am. Chem. J., viii., 206 and Ber. xix. (c), 708.
4. *Wieland.* Ber., xvii., 1611.
5. *G. Neumann.* J. S. C. I., vii., 343.
6. *J. Krutwig.* Ber., xv., 1264.
7. *Beilstein and Jawein.* Ber., xii., 759.
8. *Beilstein and Jawein.* Ber., xii., 446.
9. *E. Smith.* Am. Chem. J., ii., 41.
10. *T. Moore.* Chem. News, liii., 209.
11. *Kohn and Woodgate.* J. S. C. I., viii., 256.

Cd. is precipitated as metal from the double sodium acetate with acetic acid (Smith, Ber. xi., 2048). Also from double tartrate with tartaric acid (Smith and Knerr Am. Ch. J., viii., 206 and Ber., xix., 708).

Zn. from double acetate with citric acid (Parodi and Mascazzini Zeits. Anal. Chem., xvi., 649), also (Luckow, Jahresber, 1865, 686). Also from double ammonium acetate with acetic acid. Riche.

Ur. separated at the cathode as $Ur(OH)_2$ from double sodium or potassium acetate (Smith, Ber., xiii., 751).

Electrolytic Assay of Copper Ores, etc. W. Glenn (*Trans. Min. Eng.*, New York Meeting, February, 1889).

The cell recommended is one having a capacity of somewhat under 3500 c.c., the porous cup holding about 500 c.c. Bunsen elements (carbon

and zinc). The porous cup is filled with a solution made in these proportions: Sulphuric acid (47 Bé), 1 litre; water, 1 litre; sodium dichromate, 200 grammes. The outer cell is about one-third filled (7 to 8 cm.) with water. Such a cell will precipitate the copper in one to four assays, working over night (about 2 grammes Cu). The use of any nitric acid in the electrolyzed solution is carefully avoided. For ores about 2 grammes are taken, and treated with 17 c.c. nitric and 3 c.c. sulphuric acid (conc.). This is evaporated, finally heating to strong fumes of sulphuric acid. After cooling, 60 c.c. water are added, and after boiling and filtering, divide the solution for electrolyzing. With bar copper, 15 grammes or more are taken, using an excess of nitric acid, and a little more than the theoretical quantity of sulphuric. Cylinders are preferred to dishes, since the solutions, especially when containing nitric acid, seem prone to deposit Fe_2O_3 (or some other oxide). It may be necessary to precipitate the small amount of copper not deposited by H_2S, and determine by weak KCy (6 grammes per litre).

Electrolytic Detection of Mercury. Wolff (*Zts. Augen. Chem.*, 1888, 294).

The positive electrode is a platinum spiral fitted inside of a glass tube; the negative electrode, a smaller steel spiral which has first been coated with copper and then silvered. In the material to be tested, organic matter is first destroyed by HCl and $KClO_3$, then after acidifying with H_2SO_4, the solution is passed three times through the tube. The steel spiral is then sealed up in a long-necked bulb, and the mercury volatilized to the cooler end. By introducing iodine vapor afterward, the characteristic test is obtained. 0.00001 gramme Hg in 100 c.c. has been thus detected.

Electrolytic Separation of Mercury from Copper. Smith and Frankel (*Am. Chem. Jour.*, xi., 264).

By using a solution containing excess of alkaline cyanide it was found possible to separate the mercury, though the copper retards its separation. The separation of silver from copper could not be thus effected.

Chlorine, Bromine, Iodine and Sulphur in Organic Compounds. Marsh (*Am. Chem. Jour.*, XI., 240).

The substance is carefully heated in a small test-tube with an equal bulk of zinc powder. On adding a little water, the $ZnCl_2$, $ZnBr_2$ or ZnI_2 is dissolved, and the halogen may be detected by suitable reagents. The addition of HCl to the portion insoluble in water affords H_2S if sulphur were present.

Sulphur in Coal. Brullé (*Mon. Sci.*, 1889, 230).

A platinum boat 30 cm. long, 15 mm. wide and the same depth, is used. In this is placed 1 gm. of the coal, together with 20 gms. of a mixture of equal parts of sodium nitrate and carbonate. A layer of the same mixture, together with some $KClO_3$, is laid on the top. The heat is applied progressively from one end. Higher results are obtained in this manner than by other methods.

Hydrosulphuric Acid. De Koninck (*Zts. Angew. Chem.*, 1888, 311; *Jour. Lond. Chem. Soc.*, 1889, 437).

The gases are passed through a solution containing $HgCy_2$ and NH_4Cl. H_2S gives a flocculent precipitate, which is easily washed, and can then be oxidized with Br. The $HgBr_2$ is readily volatilized, and the sulphur can be determined as usual by precipitation with $BaCl_2$.

Insoluble Phosphates. V. Edwards (*Chem. News*, lix., 159).

As a rapid and approximate method 5 grms. of the sample are first treated, as usual, to extract soluble phosphates; the residue is digested for about thirty minutes in nitric acid, with addition of some HCl, a known amount of $Ca_3P_2O_8$ in solution added, and after filtering and making up to 250 c.c., 50 c.c. is titrated with uranium acetate. An allowance of 0.5 per cent. is made for phosphoric acid held back by iron and alumina in the sample.

Phospho-Molybdate Precipitate. F. Hundeshagen (*Fres. Zts. Anal. Chem.*, xxviii., 141).

The precipitate, dried over calcium chloride, had the composition $12\,MoO_3$, $PO_4\,(NH_4)_3$, $2HNO_3\,H_2O$, when precipitated from nitric acid solution. From HCl the composition was the same with the substitution of 2HCl for $2HNO_3$. Dried at 130° to 150° C., it had invariably the composition $12MoO_3$, $PO_4(NH_4)_3$; 5 to 10 per cent. of ammonium nitrate in the solution was the best proportion to effect rapid separation; about four times as much KNO_3 was required to produce the same effect. Rapidity, but not completeness of separation, was increased by heat, concentration and agitation. In the cold the precipitate was granular; when hot, crystalline. The minimum amount of nitric acid necessary for complete precipitation was 23 molecules to 1 molecule of precipitate. Over 100 molecules HNO_3 interfered with the formation of the precipitate; 2000 molecules prevented it altogether. This interference was, however, neutralized by increasing the excess of MoO_3 in the solution, more than double the theoretical amount being required, when 2000 mol. HNO_3 were present. Sulphuric acid and sulphates rendered precipitation slow. In comparatively large proportions, they prevented it, more or less completely. The presence of borates did not interfere, if enough nitric acid (+ 23 mol.) were added to set free all boric acid. NH_4Cl or NH_4NO_3 solutions if acidified, had no effect on the precipitate. Hot or even cold water, caused partial dissociation and solution. Many chlorides and nitrates, notably those of sodium, had a similar effect, also alkaline solutions, salts of polybasic mineral acids, or salts of monobasic organic acids. In all the above cases the precipitate can be re-formed by addition of HNO_3 and NH_4NO_3. Decomposition and partial solution is also effected by salts of polybasic organic acids, but under these conditions, the precipitate cannot be reproduced as before. The precipitate is attacked by mineral acids, least by HNO_3 most by H_2SO_4; HCl occupies an intermediate position in this relation.

For washing the precipitate are recommended:

5 per cent. solution of NH_4Cl or NH_4NO_3 acidified or neutral; 5 to 10 per cent. solution of $(NH_4)_2SO_4$ acidified.

Cold dilute HCl or HNO_3 ½ per cent. or ice-cold water, if the washing solution is not long in contact with the precipitate.

Modification of Pemberton's Method of Titration.

Dissolve in 1 litre—10 gms. MoO_3—or 12.262 gms. pure $(NH_4)_2MO_4$—dissolved in dilute NH_4HO, neutralize with dilute HNO_3 add 15 gms. HNO_3 (= 39 cc. HNO_3 of Gr. 1.2) and dilute.

Of this solution 24.3 to 24.5 cc. precipitates 0.01 gm. P_2O_5.

The solution of phosphate should be neutral or weakly acid, and should not contain over 0.025 gms. P_2O_5 per 100 c.c. Add 10 to 15 gms. NH_4NO_3 per 100 c.c.; heat nearly to boiling. Run in the MoO_3 solution and stir in. Toward the last, run the MoO_3 solution against the side, so that it spreads in a layer over the surface, and observe if there is any precipitate at the point of contact. When none appears, the titration is finished. If the same conditions are produced, MoO_3 can be titrated with a standard solution of phosphate.

Direct weighing of the precipitate.—Dissolve in ammonia, filter from shreds of filter paper, etc., evaporate off almost all the NH_3, add dilute HNO_3 to complete precipitation. Heat to 160°–180° until all NH_4NO_3 is volatilized, and weigh. The proportion of phosphoric acid in the precipitate thus obtained was slightly lower than the theoretical amount.

Indirect titration of the precipitate.—Wash with 5 per cent. NH_4NO_3, stir up in cold water, add phenolphthalein, run in tenth normal soda, until the tint is decided. Titrate back rapidly with tenth normal HNO_3, 1 c.c. tenth normal NaOH = 0.016322 phospho-molybdate = 0.00061739 P_2O_5 = 0.015026 MoO_3.—23 mol. NaHO needed to neutralize 1 mol. of precipitate. *Or*, precipitate by HNO_3 from neutral solution, dissolve in ammonia, neutralize, and run in tenth normal HNO_3 to complete precipitation. 26 mol. HNO_3 required.

1 c.c. standard HNO_3 = 0.01444 Phospho-molybdate = 0 00054616 P_2O_5 = 0.0132923 MoO_3.

Kjeldahl Process Applied to Water Analysis. Drown and Martin (*Techn. Quarterly*, ii., 3).

500 c.c. of the water are taken, and 200 c.c. distilled off, in which if desired the free ammonia may be determined. Then 10 c.c. conc. H_2SO_4 are added, and the solution is boiled down in the flask until the acid is concentrated, and the solution is pale yellow or colorless. Pulverized permanganate is then added as usual, until the solution remains green, then 200 c.c. water and 100 c.c. of NaHO solution (200 grms. per litre). This is then distilled into very dilute HCl (1 c.c. = 0.5 mg. NH_3), the first 50 c.c. being distilled off rather slowly. Then the distillation may be carried forward more rapidly, until 150 to 175 c.c. have come over. The distillate is then made up to 250 c.c., and aliquot portions nesslerized.

Nitrates and nitrites apparently do not affect the results materially.

The most scrupulous care is necessary to insure the absence of ammonia from the reagents and apparatus employed, and the process must be carried entirely through with as little delay as possible. A blank test of all the reagents will be necessary.

The use of permanganate does not seem to be indispensable.

Leffman and Beam (*Am. Chem. Jour.*, xi., 274) propose a modification of the above. In addition to the reagents used, they prepare also a solution of Na_2CO_3 (200 grms. per litre). As with the NaHO, the

material is dissolved in the requisite quantity of water, boiled down to half its bulk, and after cooling diluted to 1 litre.

2 c.c. each of the NaHO and Na_2CO_3 are mixed with 200 c.c. of the water in a stoppered flask, and after thorough shaking allowed to stand an hour or two. On filtering through cotton previously well-washed with ammonia free distilled water, an aliquot portion is nesslerized for free ammonia. The first portions of the filtrate are rejected. For total nitrogen another portion of the water, 500 c.c., is taken, boiled down with 10 c.c. conc. H_2SO_4 as usual, then after cooling 50 c.c. of water, a slight excess of NaHO (about 150 c.c.) and 2 c.c. of Na_2CO_3 is added, the mixture when cold being finally made up to 250 c.c. After agitation and allowing to stand as before, filtration through cotton and nesslerizing as previously described completes the operation. Distillation is thus dispensed with. The results quoted seem to show that with contaminated waters Drown and Martin's process gives somewhat lower figures than by this method.

Nitric Nitrogen by Kjeldahl. Foerster (*Chem. Zeit. Rep.*, xiii., 229).

To 0.5 gm. of the substance is added 6 per cent. of phenol sulphuric acid. When dissolved, 1 to 2 gms. hyposulphite are added, and after decomposition, 10 c.c. conc. N_2SO_4 and HgO, the remainder of the process being conducted as usual.

Nitrous Acid in Water. Mussett (*Chem. Zeit. Rep.*, xiii., 102).

ZnI_2 may be decomposed by bacteria present in the water. If, however, acid is added, and the nitrous acid distilled over with the water, the test may be applied in the distillate.

Colorimetric for Nitrates in Water. S. C. Hooker (*Am. Chem. Jour.*, xi., 259).

The solutions required are:

1. Concent. H_2SO_4 (Gr. at least 1.84).
2. Acetic solution of carbazol, 0.6 gms. in 90 c.c. of about 100 per cent. $HC_2H_3O_2$, diluted to 100 c.c.
3. H_2SO_4 solution of carbazol., 15 c.c. of 1 with 1 c.c. of 2; let stand about two hours.
4. KNO_3 0.7214 gm. per litre.
5. $Al_2(SO_4)_3$, 5 gms. per litre.
6. Ag_2SO_4 4.3943 gms. per litre.

If solution 1 dissolves carbazol with yellow or brown coloration at first, it is sufficiently pure.

Iron, when over 0.1 per 100,000, interferes. It can be removed by rendering the water alkaline, evaporating to dryness, and redissolving in the same volume of distilled water as was originally taken.

Chlorine interferes. Remove by adding the necessary amount of solution 6 (found by titration), to 100 c.c. of the water, adding 2 c.c. of solution 5 to cause ready separation, diluting to 100 c.c. and filtering. The first portions passing through the filter are rejected. An allowance is made in the results for this dilution.

To make the test, 2 c.c. of the water is well mixed with 4 c.c. of solu-

tion 1 and cooled; then 1 c.c. of solution 3 is added and well mixed in. Comparison solutions are prepared from solution 4, diluted ten times, and treated in the same way.

As the coloration alters by standing, a preliminary test is made to find the approximate amount, and after making the standards, a fresh test is made, the reagent being added to all at the same time, as nearly as possible. Test-tubes of uniform calibre must be used, and the colors compared by looking *across* the tube. Nitrites when estimated in this way give readings about one-fifth too high, estimating as N.

Carbon Monoxide in Air. Reverdin (*Chem. Ztg.*, xii. 1726).

The air is filtered through mineral wool, then heated to 150°, passed over iodic acid, and then into starch solution. CO is converted to CO_2, iodine being liberated, which may be determined by well known methods.

The Meldometer. Joly (*Industries*, 1889, 20).

This apparatus has been devised for determining the melting and boiling points of small quantities of substances. It consists essentially of a platinum ribbon through which a current of electricity can be passed, which is mounted over a microscope stage. The strength of the current is regulated by a carbon-mercury rheostat. The substance to be examined is placed on the ribbon within the field of the microscope, and the current increased gradually so as to raise the temperature to the required point.

New Elements.

Gnomium is the name given by Dr. Krüss to the metal discovered by him as present in nickel and cobalt.

K. D. Chrustschoff has announced to the Russian Mineralogical Society, the discovery of another element which he has named Russium. In properties it somewhat resembles thorium. It is reported to fill a vacancy in Mendeljeff's table of the elements.

MINERALOGY, BY A. J. MOSES.

*CARYOPILITE, *A. Hamberg.* $Mn_4Si_3O_{10}+3H_2O$ (*Approx.*)

From Harstig mine near Pajsberg, Sweden. Botryoidal with fibrous structure. Color, brown; H. 3.5; G. 2.83—2.91.—*Geol. För. Förhandl*, v. xi., 27, 1889.

CELESTITE *with Inclusions of Sulphur.*

A specimen from Girgenti on which were long, thin, well formed crystals of celestite in part clear and transparent, and in part opaque and of a dirty lemon color, but equally brilliant throughout and constant in angles.

Analysis showed sulphur 13.69, celestite 86.31 per cent.—H. J. Johnstone-Davis, *Mineralogical Magazine*, vol. viii., p. 28, May, 1888.

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* Taken from Abstract in *Am. Journ. Sci.*, June, 1889.

DESCLOIZITE *and the allied Vanadates.*

Descloizite (*a*)	Vd_2O_5 :	(PbO,ZnO,MnO) = 5 : 3.2
Descloizite (1)	"	(PbO,ZnO,MnO) = 5 : 3.8
Cuprodescloizite (2)	"	(PbO,ZnO,CuO) = 5 : 4.2
Psittacinite (3)	"	(PbO.ZnO,CuO) = 5 : 3.6
Laurium Vanadate (4)	"	(PbO,ZnO,CaO) = 5 : 3.4
Mottramite (5)	"	(PbO,CuO,FeO) = 5 : 5 7
Tritochorite (6)	"	(PbO,ZnO,CuO) = 5 : 3.5
Eusynchite (7)	"	(PbO,ZnO) = 5 : 3.2
Aræoxene (8)	"	(PbO,ZnO) = 5 : 2.7
Brackebuschite (9)	"	(PbO,MnO,FeO,ZnO) = 5 : 3

The first six and the last are hydrous, containing nearly the same amount of water; the other three are anhydrous. Excluding aræoxene (8), mottramite (5), and dechenite, of which further analyses are needed, there are probably only two distinct vanadates in this list.:

1st. Damour's descloizite (*a*), with which belong brackebuschite (9), eusynchite (7) and the Laurium mineral (4).

2d. Rammelsberg's descloizite (1), with which belong tritochorite (6), psittacinite (3), and cuprodescloizite (2).—F. Pisani, *Bull. Soc. Franc. Min.*, Tome xii., 38, Feb., 1889.

DESCLOIZITES *from New Localities.*

I. A vanadate from the vicinity of Zacatecas, Mexico, where it is found in considerable quantity as a blackish-green crust with galenite. It is fibrous in structure, resinous in lustre, brown on fresh fracture, yellow in powder and translucent only in thin sections. G. 6.06. The analysis corresponds to $(Pb, Zn\ Cu)_2(As, Vd)O_4OH$, which is that of a cupriferous descloizite.—*Ibid.*

II. Mayflower Mine, Bald Mt. District, Beaverhead Co., Mont. A dull yellow to pale orange uncrystallized material containing much gangue and occasionally associated with compact cerussite and galenite and a dull reddish substance containing silica, iron and some antimony. —W. F. Hillebrand, *Am. Journ. Sci.*, S. 3, vol. 37, p. 434, June, 1889.

III. Commercial Mine, Georgetown, Grant Co., New Mex. A very brilliant crystalline incrustation on quartz, consisting of more or less globular aggregates of intergrown and apparently flat microscopic crystals which project sufficiently to give a frosted appearance. At other times forming a crust upon radiating acicular and almost colorless vanadinite, which sometimes has disappeared, leaving a hollow needle of descloizite. The color varies from yellow through orange-red to deep reddish-brown, the darker colors accompanying the larger growths.—*Ibid.*

IV. Lucky Cuss Mine, Tombstone, Arizona. A more or less botryoidal incrustation upon quartz, sometimes half an inch thick. The color is a peculiar dull green, brown on fracture; streak, lemon-yellow; lustre, resinous; structure granular or subfibrous. H. 3.5; G. 5.88.—*Ibid.*

Analyses of the four are as follows:

	I.	II.	III.	IV.
PbO	53.90	55.93	56.01	57.00
CuO	8.80	1 15	1.05	11.21
ZnO	11.40	15.94	17.73	4.19
V_2O_5	17.40	20.80	20.44	19.79
As_2O_5	4.78	0.32	0.94	1.10
P_2O_5		0.27	0.26	0.19
H_2O	3.20	4.37	2.45	2.50
$SiO_2CaO,MgOCO_2Na_2O$ etc.		1 04	1.19	3.01
	99.48	99.82	100.07	98.99

DUFRENITE *of Cornwall.* $Fe''_6Fe''P_4O_{20} + 6H_2O$.

The samples analyzed were from Wheal Phœnix, Cornwall, and occurred as more or less isolated, dark olive-green internally radiated globules, upon a ferruginous quartz gangue. The globules, after breaking, were carefully picked to remove any gangue or portions showing change of color. The results were:

H_2O,	SiO_2,	P_2O_5,	FeO,	Fe_2O_3,	Al_2O_3	CaO	MgO
11.47	0.43	31.10	6.80	47.03	0.87	1.68	.17

This corresponds closely to the formula $3F_2O_3$, FeO, $2P_2O_5$, $6H_2O$, which differs very slightly from Maskelyne's formula for Chalcosiderite $3Fe_2O_3$, CuO, $2P_2O_5$, $8H_2O$.

It is suggested that the higher percentage of Fe_2O_3 found in the older analyses upon which the formula $2Fe_2O_3$, P_2O_5, $3H_2O$ was calculated, may have been due to the presence of hematite.—Prof. E. Kinch, *Mineralogical Mag.*, vol. viii., p. 112, Oct., 1888.

EUDIDYMITE, *Brögger*, $NaHBeSi_3O_8$. *Monoclinic.*

Occur at Arö, Langesundfjörd, in elæolite syenite accompanying other zeolites. It forms tabular crystals; a : b : c = 1.71069 : 1 : 1.107113 $\beta = 86° 14' 17''$. Basal cleavage easy; color, white; lustre, pearly in direction of the base; H. 6; G. 2.553.—*Bull. Soc. Franc. Min.* Tome xii., 45, Feb., 1889.

FLUOCERITE *of Österby Dalarne,* $R_2O(Fl,OH)_4$ *or* R_2OFl_4.

It occurs with gadolinite, orthite, etc., with a pegmatite gangue. Color, pale reddish yellow; lustre, wax-like; cleavage, not observed; G. 5.70; H. 4. Water and hydrofluoric acid are given off at a gentle heat. Acids decompose the powder only partially and with difficulty, concentrated H_2SO_4 decomposes it completely. The analysis showed:

Ce_2O_3	$(La,Di)_2O_3$	$(Y,Er)O$	Fl	H_2O	$CaCO_3$	
46.03	36.00	3.96	19.49	1.78	1.50	= 108.76
	Deducting O corresponding to Fl.					8.21
						100.55

This corresponds to a basic fluoride of the formula $R_2O(Fl,OH)_4$, or for pure unaltered mineral, R_2OFl_4.—M. Weibull, *Groth's Zeit. f. Kryst*, xv., Band, 431, 4 heft, 1889.

*HELIOPHYLLITE, *Flink.* $Pb_4As_2O_7 \cdot 2PbCl_2$. *Orthorhombic.*

From Pajsberg, Sweden. Sulphur yellow, foliated, H. 2, G. 6.886. —*Œfv. Ak. Stockh*, Nov., 1888.

INESITE, *Schneider* $(Mn, Ca)_3H_4Si_3O_{11}$. *Triclinic.*

Occurs at the "Hilfe Gottes" Mine, Dillenburg, Germany, with other manganese ores, in fibrous, radiating masses, the interstices of which are filled by a white carbonate. When fresh, the fibres are a

* Taken from Abstract in Am. Journ. Sci., June, 1889.

bright flesh red, the lustre silky and the hardness 6–7; but on exposure to the atmosphere it fades and whitens, loses its silky lustre and may be crumbled in the fingers. G. 3.103. An analysis showed:

SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	H_2O
43.92	0 29	0.69	37.87	8.40	0.33	9.22 = 100.72

The unaltered mineral approaches closely the formula $R_3H_4Si_3O_{11}$ in which R = Mn and Ca.—A. Schneider, *Konig. Preuss. Geol. Landes.* 1887.

KAOLINITE, *from Anglesey*, $Al_2Si_2O_7 + 2H_2O$. *Monoclinic.*

Occurs in cavities, in the line of quartz veins, in a hard blue clay slate. It is a white, glistening powder, resembling powdered starch, but under the microscope is shown to consist of hexagonal plates, with a few rhomboidal plates, arranged upon one another. Each plate is smaller than the plate beneath, but the top plate often thicker than the others. Cleavage is easily produced by pressure. By microscopic study and by measurements, the conclusion is reached that the mineral is monoclinic, with the axial angle $\beta = 83°11'$, and a : b : c : : 0.5748 : 1 : 4.7267; G. 2.62, H. 2.7.

It is scarcely attacked by hydrochloric or sulphuric acids, dissolved completely by hydrofluoric acid. Refractive index about equal Canada balsam. A former analysis, published by Dr. Percy, gives the following composition: SiO_2 46.53, Al_2O_3 38.93, H_2O 14.54 corresponding to formula $Al_2Si_2O_7 + 2H_2O$.—Allan Dick in *Mineralogical Magazine*, vol. viii., p. 15, May, 1888.

MAGNETITE (*Mangano-Magnesian*).

A mineral from New Zealand, occurring both massive and crystallized in a light yellowish-green serpentine, was found, after deducting enough MgO to satisfy the S_1O_2 as serpentine, to consist of Fe_2O_3 69.70, Mn_2O_3 3.32, FeO 20.50, MnO 1.50, MgO 4.98.—A. H. Chester, *Mineralogical Mag.*, vol. viii., p. 125, March, 1888.

MARTITE. Fe_2O_3. *Isometric.*

Careful determinations of oxygen and iron were made. The powdered substance was reduced in a porcelain tube at a bright red heat, by passing a current of hydrogen for five or six hours, collecting the water in chloride of calcium tubes, and calculating the oxygen from the weight of water. Three analyses showed

	I.	II.	III.
Iron,	70.0	70.1	69.7
Oxygen,	29.9	29.9	30.0

corresponding almost exactly to Fe_2O_3: Iron 70, Oxygen 30.

The density also was found to be practically constant: 5.197, 5.194, 5.200, 5.205 for four specimens.

The first specimen (5.197), heated in vacuum to a bright red, acquired a specific gravity of 5.223.

The change of FeS_2 to F_2O_3, without change of volume, would mean a change of density in the proportion of 3 : 2. In testing the density

of an oxide crust upon a core of pyrite, the density of 3.33 was found, which is closely ⅔ of the mean density of pyrite. It is therefore improbable that martite is an alteration of pyrite.

Typical martite, then, is homogeneous material of constant density, and with exactly the composition Fe_2O_3. Chemically there is therefore no reason to consider it pseudomorphous. Is it not necessary to admit with v. Kobell a dimorphism of FeO_3?—M. A. Lavenir.—*Bull Soc. Franc. Min.*, Tome xii., 49, March, 1889.

*METASTIBNITE, *Becker*, Sb_2S_3. *Amorphous.*

From Steamboat Springs, Cal. Brick-red, dull, apparently identical with chemically precipitated Sb_2S_3.—*U. S. Geol. Surv. Monog.*, xiii.

*OCHROLITE, *Flink*, $Pb_4Sb_2O_7 \cdot {}_2PbCl_2$. *Orthorhombic.*

From Pajsberg, Sweden. Tabular sulphur-yellow crystals, adamantine lustre.—*Œfv. Ak. Stockh.*, January, 1889.

*PAPOSITE, *Darapsky*, $Fe_4S_3O_{15}+10H_2O$.

From Paposa, Atacama, in dark red crystalline masses, with fibrous or radiated structure.—*Jahrb. Min.*, *1*, 23, 1889.

POLYDYMITE, *Laspeyeres* $(Ni,Fe,Co)_4S_5$. *Isometric.*

The chief constituent of a mass of sulphide ore from Sudbury, Ontario, was a steel-gray massive mineral which tarnishes very rapidly, and has a density of 4.541. Analysis showed

Ni	Fe	SiO_2	Cu	S.
41.96	15.57	1.02	0.62	40.80 = 99.97.

This corresponds closely to R_4S_5, and approximately to Ni_3FeS_5.

When samples of the mixed sulphides were assayed, there was found from 1.8 to 7 ozs. of platinum to the ton. It is supposed to be there as Sperrylite.—F. W. Clarke and C. Catlett, *American Journal of Science*, S 3, V. 37, p. 372, May, 1889.

QUARTZ. *Development of Lamellar Structure in Quartz Crystals by Mechanical Means.*

Quartz crystals usually exhibit a complicated lamellar structure, due to the intergrowth of two individuals in parallel but opposite directions; this may be shown by examining basal sections with convergent polarized light, or by etching such sections with hydrofluoric acid, thereby developing patterns which indicate the molecular structure.

The development of lamellar structure in crystals by pressure has not heretofore been observed in quartz, although it is a very general property of all classes of minerals, resulting, for instance, in the case of the rock-forming feldspars, from internal strains produced by the deformation of crystals from unequal contraction of the rock-mass or other external stress. The planes of lamination (gliding planes, gleitflächen,) are the planes along which chemical action most easily takes place (solution planes). In the case of a crystal of smoky quartz supposed to be from Miask Urals, lamellæ are found, which are evidently due to the action of force.

* Taken from Abstract in Am. Jour. Sci., June, 1889.

A section cut at right angles to the principal axis and examined by convergent polarized light, showed that the crystal was composed of two *left-handed* individuals, but here and there showing the phenomenon of Airy's spirals from an overlapping of right and left-handed quartz. Upon etching, the intergrowth was shown to be very complicated, small hexagons of the one individual being enclosed in the other, the planes dividing the individuals showing a tendency to parallelism to the faces of the crystal.

In certain portions of the section, alternating lamellæ were found which strikingly resembled those found in the plagioclase feldspars. There were two sets of these, sometimes broad, sometimes narrow, which intersected each other at angles of 60° and 120°.

The lamellæ developed only where the crystal had suffered injuries, and in many cases could be seen to stop short at some crack in the crystal, and further they appeared *just* in those portions which showed the Airy's spirals under polarized light. The lamellæ therefore consist alternately of right-handed and left-handed quartz, which overlap one another.

The prism face in its natural state showed only the usual striations parallel to the base, and the irregular line which marked the junction of the two individuals; when etched, however, two sets of lamellæ, intersecting each other nearly at right angles, were developed, from the position of which the planes of lamination were found to be parallel to R and — R of the crystal.

The suggestion is made that the so-called cleavage of quartz, produced by heating crystals and plunging them into cold water, is really due to a yielding of the crystals along the gliding planes and not to a true cleavage. —Prof. J. W. Judd, *Mineralogical Magazine*, vol. viii., p. 1, May, 1888.

*RHODOTILITE, *Flink*, $2(Mn,Ca)SiO_3 + H_2O$. *Triclinic.*

From Pajsberg, Sweden. Rose red, radiated, silky. H,4-5, G 3.03. —*Œfv. Ak. Stockh.*, November, 1888.

SELLAITE, *Struver*. MgF_2, *Tetragonal.*

It is found at the base of the Gebroulaz glacier, about midway between Modane and Bozel, in anhydrite with fluorite, sulphur and rarely quartz and celestite. G. 3.153.—E. Mallard, *Bull. Soc. Franc. Min.*, Tome XII. 60, March, 1889.

WEBSKYITE *Brauns* $H_6Mg_2FeSi_2O_{12}+6H_2O$ *Amorphous.*

Occurs in the palæopicrite of Amelose near Beidenkopf, as a pitch-black substance, greenish in thin splinters; sometimes with globular or reniform surface; streak, clear brownish green; lustre, pitchlike to metallic; fracture irregularly conchoidal.

Before the blowpipe it is infusible. in hydrochloric or sulphuric acid it is easily decomposed with the separation of pulverulent silica.—R. Brauns. *Groth's Zeit. f. Kryst.*, xv Band, 419. 4th heft, 1889.

* Taken from Abstract in Am. Journ. Sci., June, 1889.

CONSTITUTION

OF THE

ASSOCIATION OF THE ALUMNI

OF THE

SCHOOL OF MINES OF COLUMBIA COLLEGE

INCORPORATED MAY, 1886.

ARTICLE I.

NAME.

THE name of this Association is "The Association of the Alumni of the School of Mines of Columbia College."

ARTICLE II.

OBJECT.

The object of this Association is to promote the professional welfare of its members, and to strengthen the bonds of professional and social fellowship among the Alumni of the School of Mines.

ARTICLE III.

MEMBERS.

SECTION 1. The membership in this Association shall be: I. Active. II. Associate. III. Honorary.

SEC. 2. All graduates of the School of Mines are eligible to active membership in this Association.

SEC. 3. Persons who have completed any of the special or graduate courses of the School of Mines are eligible to associate membership in this Association.

SEC. 4. Persons eminent in science who are or have been connected with the School of Mines are eligible to honorary membership in this Association.

* It has been necessary to restrict the bulletin for this number to the new Constitution and the list of graduates.

SEC. 5. All members shall be elected by the Association upon proposal by the Board of Managers.

SEC. 6. Honorary and associate members shall have all the privileges of active members, except those of voting and holding office.

ARTICLE IV.

DUES.

SEC. 1. The annual dues of active and associate members of this Association shall be three dollars, payable in advance on the first day of October in each year. Honorary members shall not be required to pay dues.

SEC. 2. Any member not in arrears may become a life member, and be relieved from further payment of annual dues by the payment, at any one time, of fifty dollars.

SEC. 3. Members one year in arrears may, after due notification, be dropped from the roll, by vote of the Board of Managers, and shall then forfeit their rights and privileges in the Association until all arrears are paid, or until reinstated by the Board.

SEC. 4. Only those members not in arrears shall be entitled to vote or hold office.

ARTICLE V.

OFFICERS AND MANAGERS.

SEC. 1. The officers of the Association shall be a President, a Vice-President, a Treasurer, and a Secretary. These officers and eight managers, to be elected as hereinafter provided, shall constitute the Board of Managers.

SEC. 2. The President, Vice-President, Treasurer and Secretary shall hold office for one year, and are eligible for re-election. The Managers shall hold office for two years, and are not eligible for re-election until one year after the expiration of their terms.

ARTICLE VI.

ELECTION OF OFFICERS AND MANAGERS.

SEC. 1. Before the last day of June of each year the President shall appoint a committee of five active members to nominate for election by the Association for the ensuing year a President, a Vice-President, a Treasurer, a Secretary and four Managers.

SEC. 2. The Nominating Committee must send in the nominations to the Secretary not later than October 15th of each year, and such nominations shall be distributed at once to the active

members in the form of letter ballots, which must be signed and forwarded to the Secretary, and opened and counted by tellers at the annual meeting of the Association.

SEC. 3. The officers and managers must be residents of New York city or vicinity, and the four managers shall be selected, one from each of the four groups into which the Board of Managers shall, at its first meeting in each year, divide in chronological order the classes which have graduated from the School of Mines.

ARTICLE VII.

THE BOARD OF MANAGERS.

SEC. 1. The Board of Managers shall have the management of the affairs, funds, and property of the Association, and it shall be the duty of the Board to see that the purposes of the Association are carried out according to its Constitution and By-Laws.

SEC. 2. The Board of Managers shall hold at least four regular meetings during each year, namely, in the months of January, May, October, and December. Other meetings shall be called by the President as may be required.

SEC. 3. The Board shall have power to fill any vacancy in its body by the election of an active member of the Association from the group in which such vacancy occurs.

SEC. 4. A quorum shall consist of a majority of the whole Board.

ARTICLE VIII.

PRESIDENT.

It shall be the duty of the President to call and preside at all meetings of the Board of Managers and of the Association; to appoint such standing and other committees of the Association as may be found necessary or convenient for the conduct of its work, and to perform such other duties as may devolve upon him by virtue of his office.

ARTICLE IX.

TREASURER.

It shall be the duty of the Treasurer to collect and have custody of all moneys and pay all bills of the Association, but no indebtedness shall be incurred unless approved by the Board of Managers. No bill shall be paid unless previously endorsed by the Secretary. The Treasurer shall present to the Board of Managers a written report upon the financial condition of the

Association at the annual meeting in December. His accounts shall be audited by a committee of the Association appointed at the annual meeting.

ARTICLE X.

SECRETARY.

It shall be the duty of the Secretary to issue notices for all meetings of the Board of Managers and of the Association, to keep minutes of all meetings, to record the names, addresses, and professional occupations of the members, and to perform such other duties as may be assigned to him by the Board of Managers.

ARTICLE XI.

MEETINGS.

SEC. 1. The annual meeting of the Association shall be held in the last week of December in each year, unless otherwise ordered by the Board of Managers.

SEC. 2. Regular meetings of the Association for social intercourse, or for the discussion of subjects of general or of professional interest, shall be held in the city of New York at such time and place as may be directed by the Board of Managers.

SEC. 3. Upon the written request of not less than ten active members, the President shall call a special meeting of the Association, which request, as also the notice of any special meeting, shall state the object for which the meeting is called.

SEC. 4. A quorum shall consist of thirty active members of the Association.

ARTICLE XII.

SUSPENSION OR EXPULSION.

Any member of the Association may be suspended or expelled for misconduct in his relations to this Association or in his profession on proof thereof in such manner as may be prescribed hereafter by By-laws.

ARTICLE XIII.

All interest in the property of the Association of persons resigning or otherwise ceasing to be members shall vest in the Association.

ARTICLE XIV.

AMENDMENTS.

Any amendment to the Constitution must first be submitted in writing to the Board of Managers, and must be approved by a

vote of two-thirds of the whole Board before presentation to the Association. Due notice of any proposed amendment shall be sent by the Board of Managers to every active member of the Association at least one month previous to the meeting at which such amendment is to be voted upon. A three-fourths vote of the members voting, in person or by letter ballot, shall be necessary for the adoption of such proposed amendment.

BY-LAWS.

I. Unless otherwise directed the Order of Business at any meeting of the Association and its Board of Managers shall be as follows:

1. Reading of minutes of preceding meetings and action thereupon.
2. Report of the Board of Managers.
3. Reports of officers.
4. Reports of standing committees.
5. Reports of special committees.
6. Elections and announcement of elections.
7. Unfinished business.
8. New business.
9. Appointment of committees.
10. Adjournment.

II. The absence of any member of the Board of Managers from two consecutive meetings of the same, of which he shall have been regularly notified, shall be considered as a resignation on the part of such member, unless the Board shall excuse such absence. The vacancy thus created shall be filled as provided for in the Constitution.

III. The Standing Committees of the Board of Managers shall be as follows:

1. On School of Mines Quarterly.
2. On Badges.
3. On Meetings of the Association.
4. Of Conference with the Columbia College Alumni Association, and such other Committees as may be necessary.

All such committees shall, at the expiration of their terms of office, present written reports to the Board of Managers.

IV. The official organ of this Association shall be the SCHOOL

OF MINES' QUARTERLY, which will be furnished to all active and associate members.

V. The Standing Committee on Meetings shall arrange for regular meetings of the Association in October and March of each year unless otherwise ordered by the Board of Managers.

VI. These By-Laws may be amended at any regular meeting of the Association, but only by a vote of two-thirds of those present, and provided that ten days' notice in writing of the proposed amendment shall have been given to the Board of Managers, and also that notice of the same shall have been given by the Secretary in the call for the meeting.

OFFICERS AND MEMBERS OF THE ALUMNI ASSOCIATION AND ALL GRADUATES OF THE SCHOOL OF MINES.

OFFICERS.

President: Frederick Augustus Schermerhorn, E.M., '68.
First Vice-President: Sylvanus Albert Reed, Ph.D., '77.
Second Vice-President: William Bleecker Potter, E.M., '69.
Treasurer: John Krom Rees, E.M., '75.
Secretary: Pierre de Peyster Ricketts, Ph.D., '71.
Assistant Secretary: Thomas Beale Stearns, E.M., '81.

Managers.

'68. William Allen Smith, E.M.
'69. Henry Smith Munroe, Ph.D.
'69. John Cooper F. Randolph, E.M.
'74. William de Lesseline Benedict, E.M.
'76. Frederick Remsen Hutton, Ph.D.
'76. Edward Gurley Love, Ph.D.
'77. Sylvanus Albert Reed, Ph.D.
'79. Nathaniel Lord Britton, Ph.D.
'80. Wheaton Bradish Kunhardt, E.M.
'82. Alfred Joseph Moses, E.M.
'84. William Fellowes Morgan, E.M.
'84. Charles Ernest Pellew, E.M.

HONORARY MEMBERS.

*C. R. Agnew, M.D. *1888.
*F. A. P. Barnard, M.D., S.T.D., LL.D. *1889.
Charles F. Chandler, Ph.D., Professor of Chemistry, School of Mines, Columbia College. Address, 51 East Fifty-fourth Street, New York City.
Thomas Egleston, E.M., Ph.D., Professor of Mineralogy and Metallurgy, School of Mines, Columbia College. Address 35 West Washington Square, New York City.
Hamilton Fish, LL.D., Trustee of Columbia College. Address, 251 East Seventeenth Street, New York City.
George M. Miller, Montmoor, Rockland County, N. Y.
J. S. Newberry, M.D., LL.D., Professor of Geology and Palæontology, School of Mines, Columbia College. Address, School of Mines, New York City.
W. G. Peck, Ph.D., LL.D., Professor of Mechanics, School of Mines, Columbia College. Address, Greenwich, Connecticut.
O. N. Rood, A.M., Professor of Physics, Columbia College. Address, Columbia College, New York City.
L. M. Rutherfurd, 175 Second Avenue, New York City.
W. P. Trowbridge, Ph.D., LL.D., Professor of Engineering, School of Mines, Columbia College. Address, School of Mines, New York City.
J. H. Van Amringe, A.M., Ph.D., Professor of Mathematics, School of Mines, Columbia College. Address, 115 West Forty-fourth Street, New York City.
William R. Ware, B.S., Professor of Architecture, School of Mines, Columbia College. Address, 448 Madison Avenue, New York City.

REGULAR AND ASSOCIATE MEMBERS AND ALL GRADUATES.

(*Graduates not Members in Italics.*)

1867.

John Magnus Adams, A.B. 1864, A.M. 1867, E.M., Mining and Mechanical Engineer, 132 Market Street, San Francisco, Cal.

Samuel Willard Bridgham, E.M., 49 West Twenty-third Street, New York City.

Francis Gordon Brown, E.M., Merchant, 116 East Twenty-seventh Street, New York City.

Edward Stelle Bronson, A.B. 1865, A.M. 1868, E.M., 39 Garden Place, Brooklyn, N. Y.

John Adams Church, E.M. Ph.D. 1879, Mining Engineer, now in China. Address Tarrytown, N. Y.

Henry Bedinger Cornwall, A.B. 1864, A.M. 1867, E.M., Ph.D. 1888, Professor of Analytical Chemistry and Mineralogy, College of New Jersey, Princeton, N. J.

Edward Everett Giddings, E.M., Merchant, 413 Royal Insurance Building, Chicago, Ill.

Charles King Gracie, A.B. 1865, *A.M.* 1868, *E.M.* 1868, care of Aqueduct Commission, Stewart Building, New York City.

Albert Ward Hale, A.B. 1853, A.M. 1862, E.M., Civil and Mining Engineer, 280 Broadway, Room 217, New York City.

†George Edward Harding, Architect, 40 Exchange Place, New York City.

Thomas Hayes Harmer, A.B. 1864, *A.M.* 1867, *E.M.*, 113 East Twenty-seventh Street, New York City.

Frederick Milton Heath, E.M., Potsdam, N. Y.

William Wey Tuttle, E.M., Farm and Loan Agent, Springfield, Mo.

David Van Lennep, E.M., Auburn, Cal, 14

1868.

Augustus Porter Barnard, E.M. care Haukesworth & Rankin, 115 Broadway, New York City.

George Strong Baxter, A.B. Williams College 1865, E.M., Treasurer N. Pacific R.R., 17 Broad Street, New York City.

James Pettigrew Carson, E.M., Dobb's Ferry, N. Y.

Albert Huntington Chester, A.M., elsewhere E.M., Ph.D. 1878, Professor of Chemistry and Mineralogy, Hamilton College, Clinton, N. Y.

George Hampton Coursen, E.M., C.E., no address.

George Jarvis Geer, Jr., E.M., Merchant, 453 Broome Street, New York City.

George Byron Hanna, A.B. elsewhere, E.M., Assayer U. S. Assay Office, Charlotte, N. C.

**Archibald MacMartin, A.B.*, College New Jersey, 1865, and A.M., E.M. *1881.

†D. Earnest Melliss, Ph.D., 419 California Street, San Francisco, Cal.

Edward Stewart Moffatt, A.B., College New Jersey, 1863, A.M., E.M., Superintendent Scranton Iron Works, 306 Quincy Street, Scranton, Pa.

† Associate Member. Not eligible for office.

George Howland Parsons, E.M., Superintendent of Land Improvement Co., Colorado Springs, Col.

†Joseph Pope Pennington, A.M., 42 Wall Street, New York City.

William Pistor, E.M., Architect, 35 Broad Street, New York City.

Charles Slason Platt, E.M., Assayer, 4 Liberty Place, New York City.

Kenneth Robertson, E.M., Manager Iron Works, Birmingham, Ala.

Albert P. Shack, E.M., 11 West Eighteenth Street, New York City.

Frederick Augustus Schermerhorn, E.M., Trustee of Columbia College, 1877–, 61 University Place, New York City.

Lenox Smith, A.B. 1865, A.M. 1868, E.M., Trustee of Columbia College, 1883–, 3 Broad Street, New York City.

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1869.

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1870.

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1871.

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Richard Spotswood Robertson, Jr., E.M., Jackson, Minn. 7

1872.

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1873.

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1874.

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1875.

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1876.

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1877.

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1878.

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Orrien Pinkerton Downing, Ph.B., San Leandro, Cal.

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Kiúgo Nambu, E M., Tokio, Japan.

Spencer Baird Newberry, E.M., Ph.D. 1880, Professor of Chemistry, Agricultural Department, Cornell University, Ithaca, N. Y.

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Vincent Felix Pazos, E.M., Lima, Peru.

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Bailey Willis, E.M., C.E. 1879, Geologist U. S. Geological Survey, P.O. Box 591, Washington, D.C. 40

1879.

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1880.

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1881.

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1882.

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Edward Ferris Weekes, E.M., 51 New York Avenue, Brooklyn, N. Y.
William Huey Weeks, Jr., Ph.B., 789 Madison Avenue, New York City.
Herbert Percy Whitlock, C.E., 939 Park Avenue, New York City. 49

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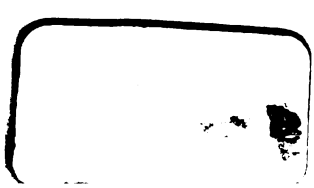
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